Severn Trent Water Ltd.

Climate Change Adaptation Report

A Response to the Climate Change Act's Adaptation Reporting Power

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Severn Trent Water
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List of Acronyms and Abbreviations

Acronym/Abbreviation	**Definition**
AMP	Asset Management Plan
CAMs	Catchment Abstraction Management Strategies
Capex	Capital Expenditure
CCWater	Consumer Council for Water
CET	Central England Temperature Record
CHP	Combined Heat and Power
CSO	Combined Sewer Overflow
DCM	Domestic Consumption Monitor
Defra	Department of the Environment Food and Rural Affairs
DOMS	Distribution Operation Management Strategy
DWI	Drinking Water Inspectorate
DWSP	Drinking Water Safety Plans
EA	Environment Agency
ELL	Economic Level of Leakage
ERM	Enterprise Risk Management System
FBP	Final Business Plan
GWMUs	Groundwater Management Units
HEP	Hydroelectric Power
ICT	Information and Communication Technology
IPPC	Intergovernmental Panel on Climate Change
KPI	Key Performance Indicator
KSI	Key Strategic Intention
Ml/d	Mega litres per day
NFU	National Farmers Union
Ofwat	Water Services Regulation Authority
Opex	Operational expenditure
PET	Potential Evapotranspiration
PR09	2009 Price Review
PR14	2014 Price Review
SDS	Strategic Direction Statement
SMD	Soil Moisture Deficit
SMP	Sewerage Management Plan
STW	Sewage Treatment Works
SWMP	Surface Water Management Plan
UKCCRA	UK Climate Change Risk Assessment
UKCIP	UK Climate Impacts Programme

UKCIP02	UK Climate Scenarios 2009
UKCP09	UK Climate Projections 2009
UKWIR	UK Water Industry Research Ltd.
WAG	Welsh Assembly Government
WFD	Water Framework Directive
WRMP	Water Resource management Plan
WRMUs	Water resource management units
WTP	Willingness to Pay
WTW	Water Treatment Works

Executive summary

In February 2010 we were directed to prepare and send a report to the Secretary of State for Environment, Food and Rural Affairs containing:

a) An assessment of the current and predicted impact of climate change in relation to the reporting authority's functions.
b) A statement of the reporting authority's proposals and policies for adapting to climate change in the exercise of its functions and the time-scales for introducing those proposals and policies.

The assessment of impact referred to above had to include:

a) A summary of the statutory and other functions of the reporting authority;
b) The methodology used to assess the current and predicted impacts of climate change in relation to those functions; and
c) The findings of the assessment of the current and predicted impact of climate change in relation to those functions.

This report meets the requirements of that Direction.

Severn Trent Water is one of the largest water and waste water companies in England and Wales. Our core business is serving 7.8 million customers over an area covering 21,000 km^2 in the Midlands and mid-Wales. Providing a continuous supply of quality water and treating waste water effectively whilst taking into account climate change and population growth, whist ensuring we protect the environment and natural resources are of paramount importance.

Global climate has changed and will continue to change with or without any reductions in greenhouse gas emissions. These changes are likely to result in both positive and negative effects on our operations. We have had first-hand experience of a number of major, severe weather events; very dry summer in 2003, very hot summer in 2006, flooding in 2007, and severe cold in December 2009 to January 2010 and December 2010, all of which have highlighted the vulnerability of our assets and services.

Climate change is already a key consideration for us and is integrated into our corporate risk management business planning and our water resource management processes. The latest climate change projections (UKCP09) have provided new insight into the scale and timeframes of the potential challenges that we may face. Reduced raw water available, decreased river water quality, increased sewer flooding, inundation of assets and increased demand for water have all been identified as climate change risks we will face by the end of the 21st Century.

Our priorities are therefore to:

- Address flood risk
- Build the resilience of our network
- Reduce sewer flooding
- Reduce leakage
- Promote water efficiency to reduce demand
- Promote catchment management

Two potential opportunities have also been identified; reduced stress on our water distribution network through warmer winter temperatures, and reduce energy input into our sewage treatment processes through increased biological activity arising from warmer temperatures.

In 2009 we submitted our five year business plan to 2014/15 to our financial economic Ofwat. Our experience of past extreme events, trends in population growth, climate change scenarios and customer's priorities were all used to inform our plans to improve and maintain our service. In order to manage the effects of climate change on our operations, we have committed in our plan to:

- Invest £1,000m to provide a continuous supply of quality water, focusing on the resilience of the network and treatment works, leakage reduction, water efficiency, flood protection, improved monitoring, distribution mains and communication pipes and in the treatment process itself.
- Invest £1,200m in waste water treatment, on resolving internal and external sewer flooding, sewage treatment standards and flood prevention.
- Invest £6m in renewable energy, building our adaptive capacity through increasing our proportion of self generation from 20% (200 GWh) to 30%[1] of total energy consumption.

We have a 25 year strategic plan and a rolling five year business planning process, we will therefore continue to develop our plans to:

- Build the outputs of this climate change risk assessment into our 25 year water resource management plan, business planning and corporate risk management processes.
- Continue to research and develop a good evidence base to inform our options identification and appraisal process to enable us to put the best business case to Ofwat in future price reviews.
- Develop practical flexible, innovative, low carbon solutions that do not contradict our key strategic intention to minimise our carbon footprint.

[1] This is a Severn Trent Plc target and includes the Non-regulated renewable generation by wind, energy crop and energy from waste

- Work with Ofwat to embed climate change adaptation into the Price Review Process
- Continue to work with our stakeholders to identify and mange any dependencies, enhance and promote sustainable catchment management activities, reduce demand through reducing leakage and increasing water efficiency and aid sustainable urban drainage and surface water management.
- Continue to identify way in which we can work with our stakeholders to breakdown barriers to adaptation.
- Find the right balance of taking action to adapt without placing an undue cost burden on our customers, or adopt capital or energy intensive approaches that could adversely impact our commitment to carbon reduction.

1. Introduction

In this Chapter we explain:

- Our business and area of operation
- Our strategic objectives
- The regulatory framework for the industry
- Our current regulatory and statutory reporting requirements
- How climate change is already affecting our operations
- Our approach to carrying our a more detailed climate change risk assessment.

1.1 Adapting to climate change

The Climate Change Act 2008 gave Government the power to direct statutory undertakers, such as water and waste water companies, to report on how their operations are affected by the impacts of climate change both now and in the future, and present an action plan to mitigate against these risks. In February 2010 we received our Direction to report to the Secretary of State for Environment, Food and Rural Affairs. We were directed to report on:

- An assessment of the current and predicted impact of climate change on our operations
- A statement on our proposals and policies for adapting to climate change
- Timescales for introducing those proposals and policies

This report presents the findings of our climate change risk assessment and our adaptation action plan and as such we described:

- Our activities, aims and strategic objectives
- The key climate change variables which have an impact on our operations
- Our methodology for carrying out our climate change risk assessment
- Our priority climate change risks and associated impacts
- Our adaptation action plan

1.2 About Severn Trent Water

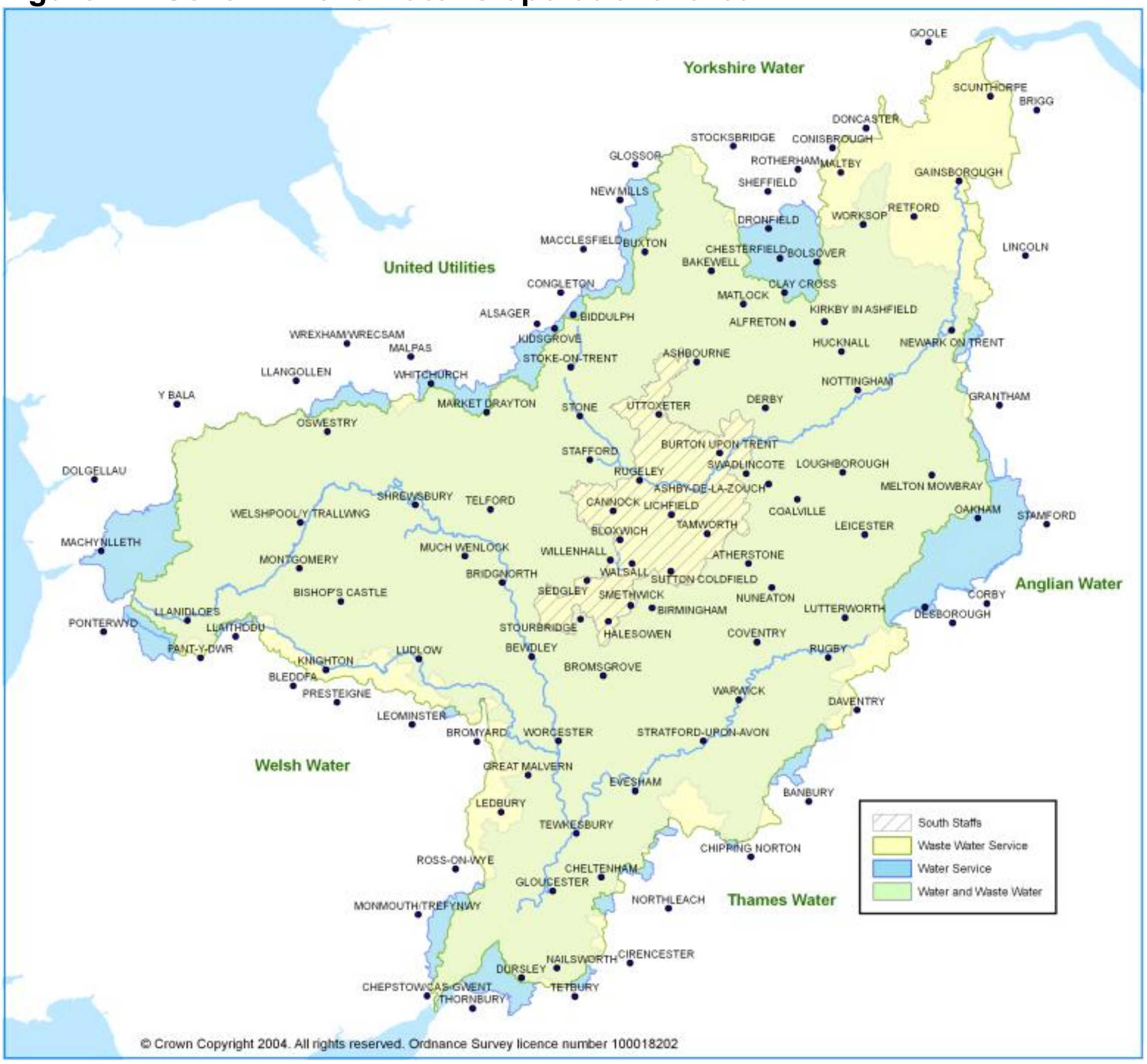
Severn Trent Water is one of the largest water and waste water companies in England and Wales, providing high quality water and waste water services to over 3.7 million households and business over an area of 21,000 km^2 in the Midlands and mid-Wales, stretching from the Bristol Channel to the Humber (Figure 1.1). We provide clean water to 7.4 million people supplying 1.8 billion litres of water per day through 134 water treatment works and 46,000 km of water mains. We currently process around 2.7 billion litres of waste water per day at through over 54,000 km of sewers[2] for treatment at 1,025 sewage treatment works. Ensuring a continuous supply of quality water to our customers and dealing effectively with waste water are, therefore, two of our highest priorities.

[2] This is likely to increase by some 27,000 km when we take on private drains and sewers from October 2011.

1.2.1 Our strategic objectives

Our goal is to be the best water and waste water company in the UK delivering the highest standards, lowest possible charges, with great people through continuous improvement and innovation. Our customer bills are now the lowest on average in the UK and the drinking water and waste water quality we provide is the best in the industry. We work continuously to improve our performance and deliver operational efficiencies against our 20 Key Performance Indicators (KPIs), which are aligned with our eight Key Strategic Intentions (KSIs)

Figure 1.1 Severn Trent Water's operational area



Our Strategic Direction Statement (SDS)[3] sets out our aims for the next 25 years and how we intend to achieve them. This was developed in close consultation with our key stakeholders including Defra, Consumer Council for Water (CCWater), the Environment Agency (EA), Natural England, Drinking Water

3 http://www.stwater.co.uk/upload/pdf/Focus_on_water_pdf_for_website_FINAL_14_DECEMBER.pdf

Inspectorate (DWI) and Ofwat. In addition, we also carried out detailed market research among our domestic and commercial customers. As a result our strategy is based on making the improvements our customers want, whilst ensuring that the economic and environmental impacts of our actions are sustainable. This strategy is reflected in our eight KSIs and climate change is embedded in each of these:

- KSI 1: Providing a continuous supply of quality water.
- KSI 2: Dealing effectively with waste water.
- KSI 3: Responding to customer's needs.
- KSI 4: Minimising our carbon footprint.
- KSI 5: Having the lowest possible charges.
- KSI 6: Having the right skills to deliver.
- KSI 7: Maintaining investor confidence.
- KSI 8: Promoting an effective regulatory regime.

The SDS formed the basis for our five year business plan[4], submitted to Ofwat in March 2009 as part of the Price Review Process, where Price Limits were set for Asset Management Plan five (AMP 5), 2010-2014. We then measure performance within each KSI against our 20 KPIs, which include leakage, pollution and net energy use. These KPIs are reviewed and updated each year to ensure continuous improvement.

1.2.2 Current statutory requirements

Since privatisation of the water industry in England and Wales in 1989, there has been a well-established framework for periodically assessing our long term investment needs. Every five years we produce a strategic Business Plan which sets out the amount of investment we require to fulfil our legal duties and meet our customers' needs. Our investment plans are driven by a number of parameters:

- Climate change
- Capital maintenance of ageing assets;
- Meeting European water quality and environmental standards
- Population and housing growth
- Deteriorating water quality.

We have established methodologies for incorporating the associated risks into our planning. Alongside the five yearly Business Plan and the Strategic Direction Statement, we also have a number of short term operational plans and long term strategic plans in place to reduce the current and future risk of supply failures during extreme weather events. An overview of the plans we already have in place and how they consider climate change risks, is given below.

4 http://www.stwater.co.uk/server.php?show=ConWebDoc.3980

Water Resources Management Plan (WRMP)[5]
We have a statutory requirement under the Water Resource Act 2003 to publish and consult on our 25 year strategy for ensuring sufficient water resources are available to meet demand. The WRMP assesses the risks to our long term supply and demand for water, and sets out our strategy for addressing those risks. The risks and uncertainties around the affects of climate change on the supply and demand for water are explicitly assessed as part of the WRMP. Our current WRMP was published in June 2010, and the climate change assessment was based on the outputs from the UK Climate Impacts Programme climate scenarios released in 2002 (UKCIP02). We have already begun assessing the implications for the WRMP based on the new UK Climate Projections 2009 (UKCP09) datasets, and we will incorporate these into the revised WRMP due for publication in 2014-15.

Drought Plan
The Water Act 2003 made it a statutory requirement for each water company to produce and maintain a Drought Plan. We published our first Drought Plan[6] in 2003 and published an updated version in 2009.

The primary objective of the Drought Plan is to set out in advance the measures that we will take during a drought to ensure a continuous supply of water to our customers, while minimising the impact to the environment. The statutory process requires us to consult with our key stakeholders when developing the plan. We have also carried out environmental impact assessments of implementing certain elements of the plan under drought conditions.

Distribution Operation Management Strategy (DOMS)
DOMS identifies our operational and capital maintenance policies and the interventions required to provide consistent or improving water quality to customers in the most cost-effective manner. It provides evidence-based justification for these requirements to company management and the economic regulator.

Drinking Water Safety Plans (DWSPs)
DWSPs form our assessment of all potential risks to water quality from source to tap. This includes assessing the adequacy of control measures in place for mitigating these risks and identifying further works required to reduce any remaining risks. This is done by assessing the water quality risks within four discrete areas; catchment, treatment, distribution and customer. The risk assessments are completed for a set list of water quality hazards. These are based on the parameters within The Water Supply (Water Quality) Regulations 2000, but also incorporate other hazards to water quality. The assessments are carried out using a matrix based on consequence and likelihood. The

5 http://www.stwater.co.uk/server.php?show=nav.6186
6 http://www.stwater.co.uk/server.php?show=nav.6371

consequence is fixed for each hazard and is based on its severity in terms of both compliance and health significance. The same matrix is used for all areas of the DWSP. The residual risks are identified at every stage, taking into account the effectiveness of all existing control measures. In order to reduce the residual risks, actions are determined - including ownership at the correct level of the organisation for each action. These actions are agreed with all parties to ensure that they are completed at the appropriate location from source to tap (e.g. a risk in the distribution system may best be addressed via an action completed within the catchment).

1.2.3 The impact of climate change on our operations to date

Climate change is a priority for us. Our SDS document sets out how climate change risks and impacts have been taken into consideration in the development of our KSIs and our five year business plan. Climate change is also a key factor in our maintaining high customer and environmental standards.

We have already had first-hand experience of a number of major, severe weather events; very dry summer in 2003, very hot summer in 2006, flooding in 2007, severe cold in December 2009 to January 2010 and December 2010, all of which have demonstrated the vulnerability of our assets and the impact of disrupted services to our customers. The impact of these events is illustrated below.

Severe precipitation during May-July 2007 resulted in:

- 3,500 customer reports of both internal and external sewer flooding, the majority associated with just four exception storm events in May 2007.
- 85 sewage pumping stations and 110 sewage treatment works suffered damage as a result of flooding. Operational capability was, in the majority of cases, restored quickly.
- In July floods resulted in the enforced shut down of the Mythe water treatment works on 22 July resulting in loss of supply to around 138,000 properties in Gloucestershire for around two weeks. A full report on this incident was published in October 2007[7].

The net cost of the flooding events of 2007, to Severn Trent Water, amounted to £13.6m. The total amount comprises costs of £29.6m identified to date, less insurance recoveries of £16.0m which have been received.

Three key issues were raised as a result of these event:

- The adequacy of the flood defences.
- The degree of water supply system resilience such that failure of a key asset can be substituted by other means without interruption of services.

[7] Gloucestershire 2007 – The impact of the July floods on water infrastructure and customer service – Final Report, Severn Trent Water, published October 2007.

- Adequacy of contingency planning.

In response to these issues, flood defences have been raised and work is being undertake to reduce the number of properties reliant upon a single source of supply.

In 2009/10 our operations were significantly affected by what the Met Office termed the 'worst winter for 30 year's. There were more continuous days with frost in 2009/10 than in any period over the last 10 years and minimum temperatures were lower than the long term average. This resulted in more severe ground penetration of frost and greater pipe stress, leading to more bursts, requiring an additional £3 million above the budget forecast to cover the cost of leakage find and repair costs. Average leakage for 2009/10 was 497 Ml/d, compared to 492 Ml/d in 2008/09 and operational leakage increased by 20Ml/d. Our winter contingency plan, however, ensured that sufficient additional resources were in place to deal with the effects of the prolonged freezing temperatures and to recover under-performance earlier in the year. In addition we significantly increased our leak detection and repair activity to address the resulting increase in leakage. As a result, the leakage for the year was below the target of 500 Ml/d to which we were committed.

The 2009/10 winter conditions also had an impact on our ability to provide customers with bills based on actual meter readings. Field activities took longer than anticipated as a result of the poor travel conditions. In order to ensure staff health and safety we ceased meter reading activity on a number of days, which amounted to the equivalent of 2,000 hours lost time. Between December 2009 and February 2010 we missed 636 appointments[8] with customers. A missed appointment can potentially carry a financial penalty, in addition to harming our customers perception of us.

1.3 Assessing climate change risks

Climate change is already inherent in our SDS, WRMP and our PR09 Final Business Plan. Furthermore climate change is also included within our corporate risk management process; Enterprise Risk Management (ERM). The ERM system considers climate change as a risk to achieving our strategic objectives and seeks to put controls in place to reduce those risks. These process have identified extreme weather as a key cause of failure to meet objectives such as meter reading and installation, failure to meet leakage targets, failure to supply continuous quality water and failure to process waste water. As a result a number of control have been put in place to minimise these risk. These include building resilience in our network, implementing our hot weather plan and raw water

[8] An appointment is defined as a specific need to meet with a customer, or a request from a customer to meet with a company representative, to discuss provisions of water or sewerage services, made 24 hours before the agreed meeting time/date.

monitoring. A full breakdown of the climate change related risks identified by the ERM process is presented in Appendix 1.

In order to carry out a more detailed climate change risk assessment to cover our entire operation and establish our priority climate change risks and an action plan to mitigate those risks we:

- Identified all of our activities
- Identified which activities were susceptible to the impacts of climate change
- Identified the nature and scale of the projected climate changes using UKCP09
- Prioritised our climate change risks
- Developed an action plan to mitigate the priority risks.

Our methodology for prioritising our climate change risks is detailed in Appendix 1, this focussed on four key areas:

- Proximity – how soon is the risk likely to have an impact
- Likelihood – probability of risk occurring
- Severity – social, economic and environmental impact of the risk occurring
- Population - size of population affected if the risk were to occur

Data used to identify the risk and resultant impact were given a pedigree score out of four, based on the methodology used by HR Wallingford in the UK Climate Change Risk Assessment (UKCCRA).

0 – Non-expert opinion, unsubstantiated workshop discussion, with no supporting evidence
1 – Expert view based on limited information e.g. anecdotal evidence.
2 – Estimation of potential impacts using accepted methods and with some agreement across the sector.
3 – Reliable analysis and methods, subject to peer review, and accepted within the sector as fit for purpose.
4 – Comprehensive evidence using best practice and published in peer reviewed literature, accepted as the ideal approach.

A confidence grade was also assigned to the risk assessment. For each risk a confidence grade of high, medium, or low was assigned.

The key climate change variables which affect our operations are discussed in more detail in Chapter 2 and Appendix 2. The outputs of our climate change risk assessment are described in full in Appendix 3.

2. Climate change

We have identified all of the activities which we undertake that are, or are likely to be, affected by climate change (see Appendix 1). The following discusses the current and projected changes in climate across the UK, and the area in which we operate.

2.1 The changing climate

2.1.1 Global climate change

Global average temperatures have risen nearly 0.8°C since the late 19th Century, rising at around 0.2°C per decade over the last 25 years (Jenkins *et al*., 2008). Furthermore Met Office/University of East Anglia data show that the global average temperature has warmed to near record levels in 2010. The preliminary figure for January to October 2010 is 0.52 °C above the long-term average, placing it equal with the record-breaking 1998 (Met Office, 2010). In addition to natural factors this increase is associated with a rise in anthropogenic greenhouse gas emissions. If no action is taken to reduce these emissions then the global average temperature is expected to increase by 4 °C by 2100.

2.1.2 National climate change

The Central England Temperature (CET) record[9] began in 1659 and is the longest continuous temperature record in existence. Until the 1980s the 20th Century was a period of relative climatic stability. In the last 30 years there has been a 1°C rise, with 2006 being the warmest to date. This is a more rapid rise than the global mean temperature. Of the 15 warmest calendar years, the CET shows that nine were between 1990 and 2007 (Jenkins *et al*., 2008)

Annual mean precipitation over England and Wales has not changed significantly since records began in 1766 (Jenkins *et al*., 2008). Seasonal precipitation is highly variable, but records broadly show an increase in winter precipitation and decease in summer precipitation. However, Marsh *et al*. (2007) show no clear trend in the frequency of drought episodes over the period 1766-2006. Data also show that the proportion of winter precipitation coming from heavy precipitation events has increased in the last 45 years (Jenkins *et al*., 2009).

2.2 Future climate changes in Wales and the Midlands

The climate variables we have assessed as being most material to our risk assessment are:

- Summer mean temperature
- Summer mean daily maximum temperature
- Summer warmest day

[9] the average of three observing stations in Worcestershire, Hertfordshire and Lancashire

- Summer mean precipitation
- Summer mean daily maximum precipitation
- Winter mean temperature
- Winter mean daily minimum temperature
- Winter mean precipitation
- Winter mean daily maximum precipitation
- Annual mean precipitation

For each climate variable we have taken the data from UKCP09 to help understand the potential impact of predicted climate change on our activities. We focussed on the projections for the Administrative Regions of Wales and the East and West Midlands as these most closely match our area of operation. As discussed in Jones *et al*., (2009) at present there is still a high degree of uncertainty in these climate change scenarios, due to natural variability, modelling accuracy and future anthropogenic emissions. We have, therefore, taken the range of emissions scenarios and probabilities into account in our assessment. For each variable, we show the projected change under each of the three emissions scenarios up to 2099. We focus primarily on the 2050s and the 2080s as the projected changes under each of the scenarios do not diverge until after the 2050s. The full datasets that have been used in our climate change risk assessment are set out in Appendix 2. The datasets show the projected change in each parameter from the long term average (1961-1990). Using the high emissions scenario, which represents a worst case scenario, and the best central estimate for a summary of the projected climate changes is provided below.

<u>The 2020s</u>
Summer mean temperature is likely to rise, with a change in °C of:
1.3°C in Wales
1.4°C in the East Midlands
1.4°C in the West Midlands
Summer mean precipitation is likely to decrease, with a percentage change of:
-4% in Wales
-4% in the East Midlands
-4% in the West Midlands

<u>The 2050s</u>
Summer mean temperature is likely to rise, with a change in °C of:
2.8°C in Wales
2.8°C in the East Midlands
2.9°C in the West Midlands
Summer mean precipitation is likely to decrease, with a percentage change of:
-17% in Wales
-16.6% in the East Midlands
-17.1% in the West Midlands

<u>The 2080s</u>
Summer mean temperature is likely to rise, with a change in °C of:
4.5°C in Wales
4.4°C in the East Midlands
4.7°C in the West Midlands
Summer mean precipitation is likely to decrease, with a percentage change of:
-26% in Wales
-25.1% in the East Midlands
-25.8% in the West Midlands

3. Priority climate change risks

The risk assessment approach is summarised in Section 1 and described in detail in Appendix 1, and full results can be found in the risk assessment matrices in Appendix 3 of this report.

The key business risks identified for Water are:

- Greater risk of droughts and consecutive dry years.
- Higher peak summer demands.
- Lower river flows (pressure on abstractions, licences and water quality).

The key business risks identified for Waste are:

- Increased frequency of overflows from sewers arising from severe storms (summer and winter).
- Inundation of treatment works and pumping stations.

The sections and tables that follow discuss these priority risks.

3.1 Water services priority climate change risks

As a result of our staged approach to assessing the risks and impacts, a total number of 52 potential climate impacts were taken through the full risk assessment process for water services. Scores ranged from five up to 45, and showed an even distribution over the full range of scores. Risks with a score of 40 or higher out of a maximum score of 50 on the risk assessment matrix were considered priority risks. Each of these activities scored highly on the proximity, likelihood, population and severity scales and received a significantly higher rating than the other issues explored in our risk assessment, which scored 37 or less and were therefore deemed less of a threat to our activities.

Several of the risks identified in our top ten will occur as a result of both increased average summer temperatures and decreased average summer precipitation. It is likely that warmer conditions will occur simultaneously with drier conditions. Therefore for ease of discussion we have grouped these risks together. The impacts and consequences around these highest rating risks are described in more detail in the remainder of this section:

- Pressure on ecological flow indicators (Section 3.1.1) – the impact of warmer and drier summers on ecological flow indicators (the key indicators are the populations of fish, invertebrates, macrophytes, phytobenthos found in rivers) in terms of river flows and our groundwater operations
- Raw water availability (Section 3.1.2) – the impact of warmer and drier summers on river levels, raw water availability and our groundwater operations
- Marginal cost of water (Section 3.1.3) – the impact of drier summers on the marginal cost of water

- Increased domestic demand (Section 3.1.4) – the impact of warmer and drier summers on Soil Moisture Deficit and domestic demand.

Table 3.1 Highest rating risks to Water Services activities

Climate Change Variable	Impact	Consequence to Severn Trent Water	Time Scale	Risk Score	Pedigree Score
Warmer summers (increased summer mean temperature)	Reduced river flow and reservoir level s puts pressure on the ecological flow indicators of water bodies.	Reductions to river abstraction licences.	By 2010s	45	2
		Reductions to groundwater abstraction licences.	By 2010s	45	2
Drier summers (decreased summer mean precipitation)	Reduced river flow and reservoir levels puts pressure on the ecological flow indicators of water bodies.	Reductions to abstraction licences	By 2020s	45	2
Drier summers (decreased summer mean precipitation)	Reduced river flows	Restricted river abstractions. Greater number of regulation days required (e.g. releases from raw water reservoirs to augment river flows) see section 3.1.2	By 2020s	40	2
		Increased frequency and duration of compensation releases from boreholes to augment river flows	By 2020s	40	2
Warmer summers (increased summer mean temperature)	Reduced river flows	Restricted river abstractions. Greater number of regulation days required (e.g. releases from raw water reservoirs to augment river flows)	By 2020s	40	2
Warmer summers (increased summer mean temperature)	Reduced raw water reservoir levels	Lower reservoir levels crossing drought trigger levels earlier and more frequently	By 2020s	40	2
Drier summers (decreased summer mean precipitation)	Reduced raw resource availability caused by low rivers flows, low raw water reservoir levels, low groundwater levels, high Soil Moisture Deficit (SMD).	Increased marginal cost of water. Impact on Company Strategy. Redeployment of staff and resources to water stressed areas.	By 2020s	40	1
Warmer summers (increased summer mean temperature)	Increased SMD.	Increased domestic demand.	By 2020s	40	2
Drier summers (decreased summer mean precipitation)	Increased SMD.	Increased domestic demand.	By 2020s	40	2

3.1.1 Pressure on ecological flow indicators of water bodies

The Environment Agency (EA) has been reviewing levels of abstraction to assess the potential for environmental damage that may be occurring as a result of unsustainable abstraction. In AMP 4[10], the EA's National Environment Project identified 12 sites within the Severn Trent Water region where our public water supply abstractions had the potential to cause adverse impacts to the aquatic environment and where further investigation was required. All 12 sites progressed to the monitoring and investigation phase. Of the 12 sites, only four have been conclusively signed off by the EA as having no significant impact on the environment. Where a significant impact has been identified, we have undertaken options appraisal to assess the costs and benefits of sourcing water in a more sustainable manner.

The EA's latest round of assessments has identified 31 additional public water supply abstraction sites in Severn Trent Water's, where further investigation is required. These sites are driven primarily by the Water Framework Directive (WFD), which places greater emphasis on the ecological status of the aquatic environment by considering four key ecological indicators in rivers:

- Fish.
- Invertebrates.
- Macrophytes.
- Phytobenthos.

It is considered that fish and invertebrates are flow sensitive, and are representative of flow conditions. Currently invertebrates are utilised as a standard monitor of the ecological health of the river, by comparing the invertebrates observed against those expected for an aquatic environment not impacted by abstraction. UKCP09 shows a trend towards warmer and drier summers. This would result in lower average river flows during summer. This would undoubtedly increase the abstraction impact, and will invariably result in a decrease in the observed ecological health of the aquatic environment.

The resulting repercussions for us are that the EA are likely to flag more of our sites for initial environmental investigation. The EA require us to interpret abstraction impacts under the worst case scenarios i.e. dry summers, and invariably, the distinction between natural river flow decreases due to climate change and river flow decreases due to abstraction impacts, will become more difficult to interpret (particularly when judged against historical data). This will result in greater difficulty for us to disprove that abstraction impacts for a given environment are significant, and it is extremely likely that the pressures on our groundwater licences will greatly increase. This is likely to result in a major increase in capital investment to determine alternative sources of water and is likely to drive extensive reviews of/and changes to our operating regimes.

[10] Amp 4 = 2005/6-2009/10.

In response to the findings of earlier investigations, the chosen mitigation option has been the use of compensation boreholes located close to the affected water course, which provides augmentation flows to the river or stream. Many of these schemes are still in operation in the our region, with Severn Trent Water owning and operating the compensation boreholes and the EA governing when they should be used and for how long. When the level of the water course drops below a certain trigger level, the compensation borehole is switched on and the abstracted water is released into the water course to improve the level or flow. During hot, dry summers the use of compensation boreholes increases in frequency and duration as the water levels drop more frequently and to lower levels. The changing climate is therefore likely to significantly impact our groundwater operations. The disadvantage of such schemes is the resultant carbon cost, not only due to the infrastructure required for such a scheme, but the operational costs. This may become more of an issue in future as one of our KSI's is to reduce carbon emissions, which may mean alternative solutions will need to be developed.

3.1.2 Reduced raw water availability

A reduction in raw water availability is likely to result due to the combined effects of reduced summer precipitation and increased summer average temperatures. The implications of reduced raw water availability are likely to be felt across our region as river abstractions are affected as well as the way we operate our raw water reservoirs. The impact of climate change on regulatory requirements is a vital consideration throughout. The strategy our regulators employ to adapt to climate change will govern our approach. These issues are discussed in more detail below.

<u>3.1.2.1 River and raw water reservoir operations</u>

In the natural hydrological system, the main influence over the volume of water within a water body (particularly rivers) is the level of precipitation, either direct or via surface runoff and infiltration. Evapotranspiration, the combined effect of evaporation from the ground and transpiration from plants, reduces the volume of water in a water body. During dry seasons, water volumes in rivers and lakes will naturally decrease. Higher summer temperatures will lead to an increase in evapotranspiration.

With the onset of drier and / or warmer conditions in the future, it is likely that the rivers in our region will be affected. We anticipate that as a result our rivers will receive less runoff, with the river catchments being affected by increased evapotranspiration.

In 2009 we commissioned a report with the aim of making an initial assessment of the potential impact of climate change on our surface water resources based on the UKCP09 projections (Mott MacDonald 2009). The report focussed on changes in precipitation and potential evapotranspiration (PET) in five of our river catchments (out of 65) by the 2020s and began to quantify the impacts in terms of changes in the river flows. To make this initial assessment the UKCP09 Weather Generator tool was used to generate monthly precipitation and PET factors (as a percentage change) for each of the five catchments.

Figure 3.1 shows the percentage change in projected monthly precipitation by the 2020s, averaged across the five catchments. The graph also shows the change in precipitation projected using the UKCIP02 climate scenarios (analysed in 2008), which were used in our assessment of the impacts of climate change for our 2009 Final Water Resources Management Plan. Precipitation is likely to increase during the winter months and decrease during the summer months. The UKCP09 projections show less extreme winter increases and summer decreases in precipitation in these five catchments than the previous projections. Similarly, Figure 3.2 shows the changes in PET projected using both UKCP09 projections and the UKCIP02 scenarios. Under both sets of projections PET is anticipated to increase, however UKCP09 projects a far greater increase throughout the whole year than UKCIP02. Although precipitation is projected to increase in the winter months, the increase in PET will counter the effect, resulting in river flows being reduced (as shown in Figure 3.3). Reduced precipitation in the summer months, combined with increased PET will cause river flows to drop considerably, potentially by 20% in the height of summer. This could pose a significant risk to our operations, particularly in terms of the quantity of raw water we will be able to abstract from rivers. In order to reduce this risk we would need to optimise our winter storage and use ground water when river flows are low.

Figure 3.1 Comparison of precipitation changes under UKCP09 and UKCIP02 projections

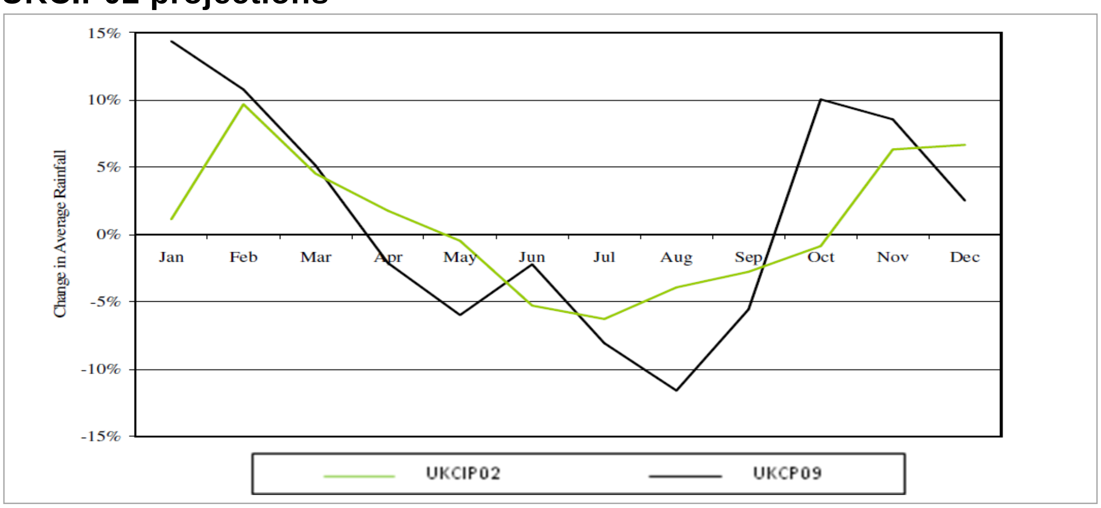


Figure 3.2 Comparison of PET changes under UKCP09 and UKCIP02 projections

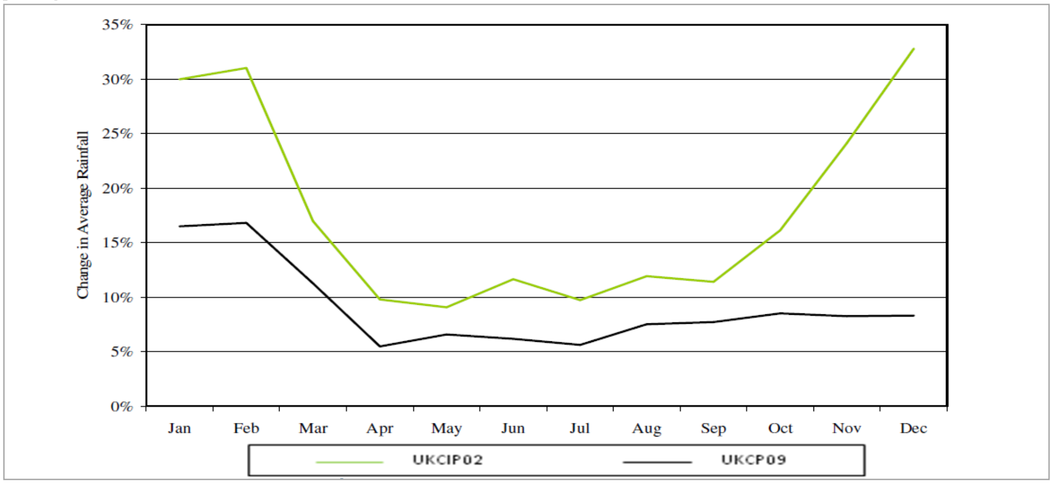
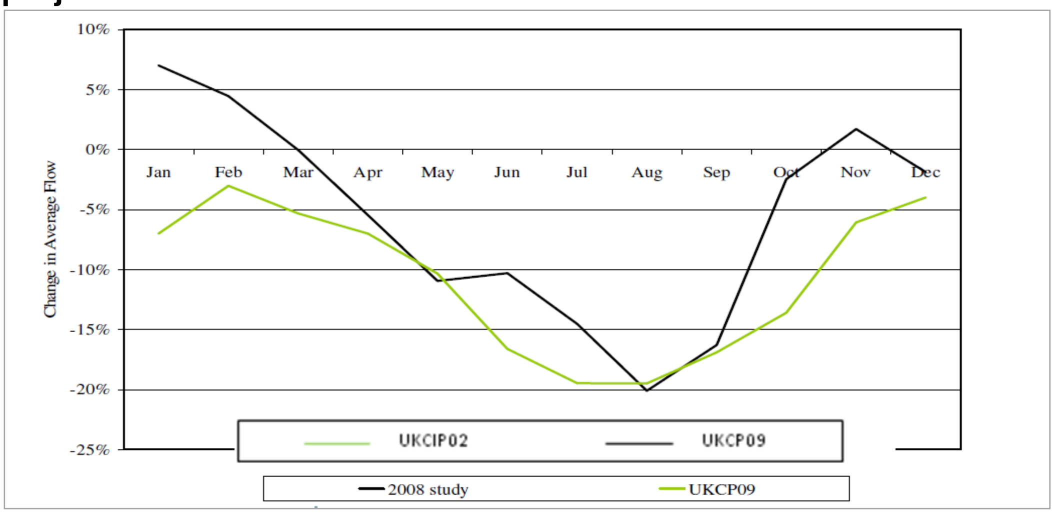


Figure 3.3 Comparison of flow changes under UKCP09 and UKCIP02 projections



Problems occur where the volume or quantity of water abstracted is greater than the amount of water replaced via natural and controlled processes, such as compensation releases from reservoirs or boreholes to augment low river flow. This is of particular concern during dry seasons, where reduced precipitation leads to 'low flows'. Abstraction at times of low flow can lead to the volume of water dropping to below certain 'threshold' levels, whereby environmental damage could occur. Over abstraction during periods of low flow leads to:

- Reduction in water availability for water dependent and water related habitats and species (particularly designated sites of nature conservation value).
- Increased susceptibility to water pollution and eutrophication.
- Reductions in water quality due to increased concentrations of pollution.

- Reduced navigability of rivers and canals.
- Reduced access to watercourses for recreational purposes.
- Reduced availability of water for customers.
- Interruptions to water supply for customers.

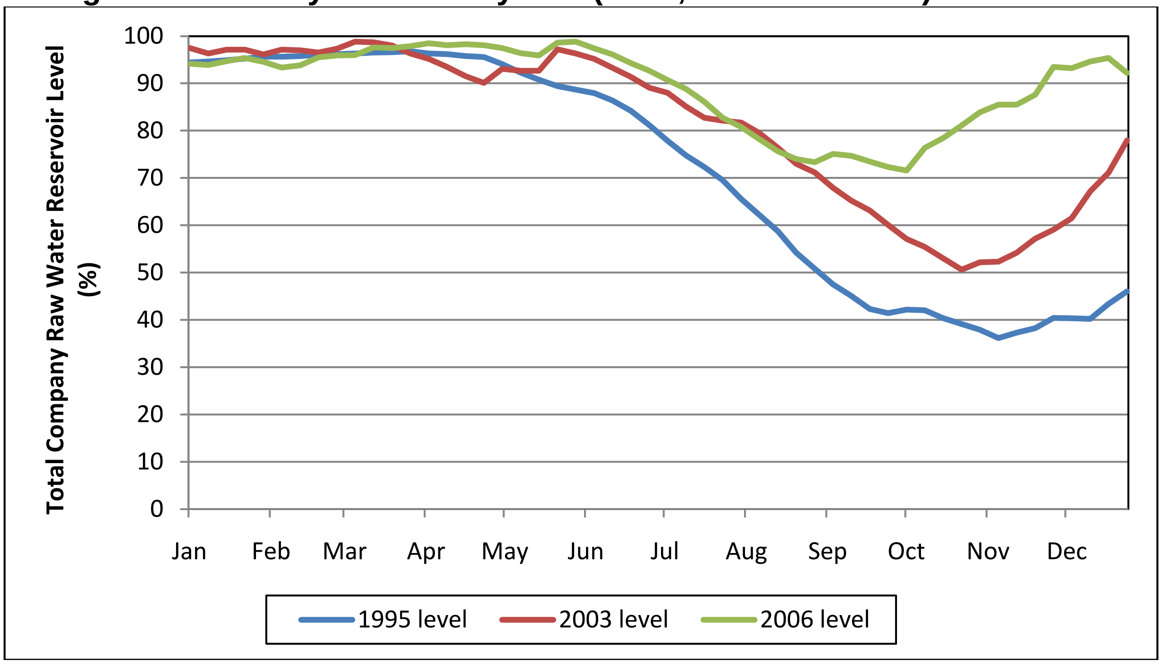
Some of our current abstraction licences are limited when river levels are low. If in future it becomes the norm for river levels to be around 20% lower throughout the summer than current levels due to reduced precipitation and increased summer temperatures, our operating practices will need to change to help us adapt.

In terms of our operations, low river levels will not only affect our abstractions directly from rivers, they will also affect the way we use our raw water reservoirs. Increased usage of our raw water reservoirs will be required in order to offset reduced river abstractions. Figure 3.4 shows how much our raw water reservoirs were drawn down during our key years of 2003 and 2006 and the drought year of 1995. These are key years as we experienced peak demand for water in summer of 2003 and 2006, which were also periods of high summer temperature and low summer precipitation. As the graph shows, significant draw down of the reservoirs began in the June of each year.

We have analysed weather data from 2003, 2006 and 1995, using the UKCP09 joint probability plot tool to give context to our current operations in periods of hot, dry weather against potential future conditions (See Appendix 2). Our analysis shows that by the 2050s, the extreme weather conditions experienced during the summer of 2003 are likely to become more like the norm. During 2003, our raw water reservoirs were drawn down to 50% by October. Under these circumstances we need to be able to optimise use of our pumped storage reservoirs which are refilled using water pumped from the rivers during the winter months. However, the level of the river determines how much water we are able to abstract to store in our “pumped storage” reservoirs – if the river level is low, then abstraction restrictions apply to prevent the rivers dropping below a sustainable level. The use of the Joint Probability Plots is discussed in more detail in Appendix 2

As discussed in Section 3.1.1, we currently operate compensation schemes whereby water is abstracted using a compensation borehole and released into a nearby water course which is being affected by low river flows. Similar compensation schemes are operated using our raw water reservoirs, with water being released from the reservoirs to augment flows in the connected river. If the flow drops below a certain level, greater releases are required. However, low river levels are likely to coincide with periods of high demand, as both river levels and domestic demand are influenced by the weather. This puts additional demand on the reservoir, causing reservoir levels to drop sharply unless the situation is carefully managed. If the conditions experienced during 2003 are going to become a regular occurrence, our raw water reservoirs will be put under more stress and are likely to cross drought trigger levels more frequently.

Figure 3.4 Historic draw down curves of Severn Trent Water's raw water storage levels is key threshold years (1995, 2003 and 2006)



3.1.2.2. Drought Management

Specific areas in our region are already more prone to the affects of drought than other areas. In our drought contingency planning we have identified six locations where Drought Permits would be requested if a drought occurred[11]. The Severn Trent Water areas affected are:

- The Derwent Valley Reservoirs, where we would request a reduction in the compensation requirement.
- The River Derwent at Ambergate, where we would seek to vary the prescribed flow at Derby to allow greater winter refill of Carsington Reservoir.
- The Tittesworth Reservoir and River Churnet Conjunctive Use Area, where we would request variations to the compensation requirements from Tittesworth Reservoir and Deep Haye Valley and to the abstraction licences for our sources in the Leek Groundwater Unit. This will assist the refill of Tittesworth Reservoir.
- The River Wye at Wyelands, where a variation to the abstraction licence restrictions would be sought, to allow greater support from the River Wye to the Lower Severn and Forest of Dean supply areas.

[11] The drought permit application is a legal process by which the EA can grant a water company a temporary abstraction permit, a variation to an existing abstraction licence or a variation to a compensation requirement, to enable continued provision of water for public consumption.

- The River Severn at Trimpley, where we would seek to vary the abstraction restrictions imposed during maximum regulation of the River Severn. Regulation of the River Severn is a responsibility of the EA, who control how much water is released from a series of reservoirs and boreholes towards the head of the river. Varying the abstraction restrictions will allow greater conjunctive use of the River Severn and River Wye systems especially when storage in the Elan Valley Reservoirs is low.
- The River Leam at Leamington and the River Avon at Stareton, where we would request a variation to the prescribed flows to assist the refill of Draycote Reservoir.

Changes in the climate which result in reduced river levels are likely to significantly affect on the way we operate, particularly during a drought. If dry year conditions, such as those experienced during 2003 become the norm, it is likely we will need to instigate our “hot weather contingency” and “drought” plans on a more regular basis in order to deal with the affects of changing weather. It is possible that we will need to seek Drought Permits more frequently than we currently do, which will impact not only the way we operate as a company, but the way the regulators will need to operate as well.

<u>3.1.2.3 Regulation</u>
Water resources in England and Wales are managed by the EA. One of the ways that this is done is through licensing the abstraction of water. As part of this responsibility it has prepared or is in the process of preparing Catchment Abstraction Management Strategies (CAMS) for all catchment areas. The purpose of these CAMS is to:

- Inform the public on water resources and licensing practice.
- Provide a consistent approach to local water resources management.
- Help to balance the needs of water users and the environment.
- Involve the public in managing the water resources in their area.

The CAMS set out how, by assessing water availability within catchments and managing the granting of abstraction licences, the EA seeks to protect the water environment by preventing over abstraction during periods of low flow. This has been achieved by identifying the ‘resource availability status’ for specific Water Resource Management Units (WRMUs) and Groundwater Management Units (GWMUs) within individual catchments (Severn Trent Water Ltd, 2010).

There are a number of WRMU within the Severn Trent region that are already designated by the EA through their CAMS assessments as being over licensed or over abstracted. For most WRMUs that are over abstracted or over licensed, the EA has indicated that no new licences will be granted or has placed restrictions on future abstractions, whereby licences will be subject to “Hands Off Flow” conditions (a condition attached to an abstraction licence which states that if flow in the river falls below the level specified on the licence, the abstractor will be required to reduce or stop the abstraction) during periods of low flow. Therefore when considering our long term supplies from rivers, we may need to consider alternative sources where there is sufficient flow for abstractions to be granted throughout the year. This will, however, increase pressure on resources in other locations.

Over the next five to ten years we will be investing in new schemes that will allow us to maximise the sustainable use of our existing abstractions. For example, we are duplicating a section of our Derwent Valley Aqueduct to release available resources and treatment capacity in the north of our region which will provide greater security of supply to customers in the south of the region. At the same time we will be investing in measures to reduce the demand for water, such as reducing the amount of water lost through leakage and helping our customers become more efficient in their water use.

3.1.3 Marginal cost of water

The Economic Level of Leakage (ELL) is the point at which the cost of reducing leakage is equal to the additional benefit reducing leakage achieves. It relies on two key relationships as outlined by Ofwat:

- The costs of the various activities for controlling leakage (such as finding and repairing leaks) and how they vary with the level of leakage.
- The impact that different leakage levels have on the costs of delivering water to customers (such as treatment and pumping costs) and the timing of planned new supply, treatment and demand management (including water efficiency) schemes.

ELL values vary over time and are influenced by changes in leakage practices and technologies, and the marginal costs of water. The marginal costs of water are dependent upon, amongst other things, the increased use of the more expensive sources, as demand increases and/or as cheaper sources become depleted.

UKCP09 shows a trend towards warmer drier summers. If precipitation decreases and resources become more stressed, the marginal cost of abstracting, treating and pumping water will rise due to the increasing scarcity of raw water, deteriorating raw water quality and the need for new sources of water to be developed. As the marginal cost of water supply increases over time, this will impact our supply / demand investment strategy because it will make leakage reduction measures increasingly economic.

As we prepare our 2015 Water Resources Management Plan we will be developing our understanding of what the UCKP09 scenarios mean for water resources in our region. Through this analysis we will identify the potential economic scope for driving down leakage across our region.

3.1.4 Increased domestic demand

The domestic demand profile across the Severn Trent Water region generally remains relatively steady over the winter months. Demand only tends to increase during the winter as a result of increased leakage due to the freeze-thaw action of frosts. However, domestic demand increases significantly between May and August when the weather becomes hotter and drier.

Our Domestic Consumption Monitor (DCM) team has carried out an analysis of domestic demand data across our region, identifying a relationship between Soil Moisture Deficit (SMD) and domestic demand. Soil Moisture Deficit is the difference between the amount of water actually in the soil and the amount of water that the soil can hold. Our analysis shows that during the summer of 2003 (the last significantly hot and dry summer in our region) once SMD reached 60mm, we saw an increase in domestic demand.

Figure 3.5 shows the average monthly household consumption and SMD levels in the Severn Trent Water region during 2003-04. The graph clearly shows a correlation between household consumption levels and SMD levels; as SMD levels get higher, household consumption levels increase. Household consumption remained relatively high during the whole of May to October during 2003. The Soil Moisture Deficit remained above 60 mm for the whole of this period. In a normal summer, we would expect demand to remain high during May through to the end of August.

Figure 3.5 Monthly household consumption and Soil Moisture Deficit in 2003-04

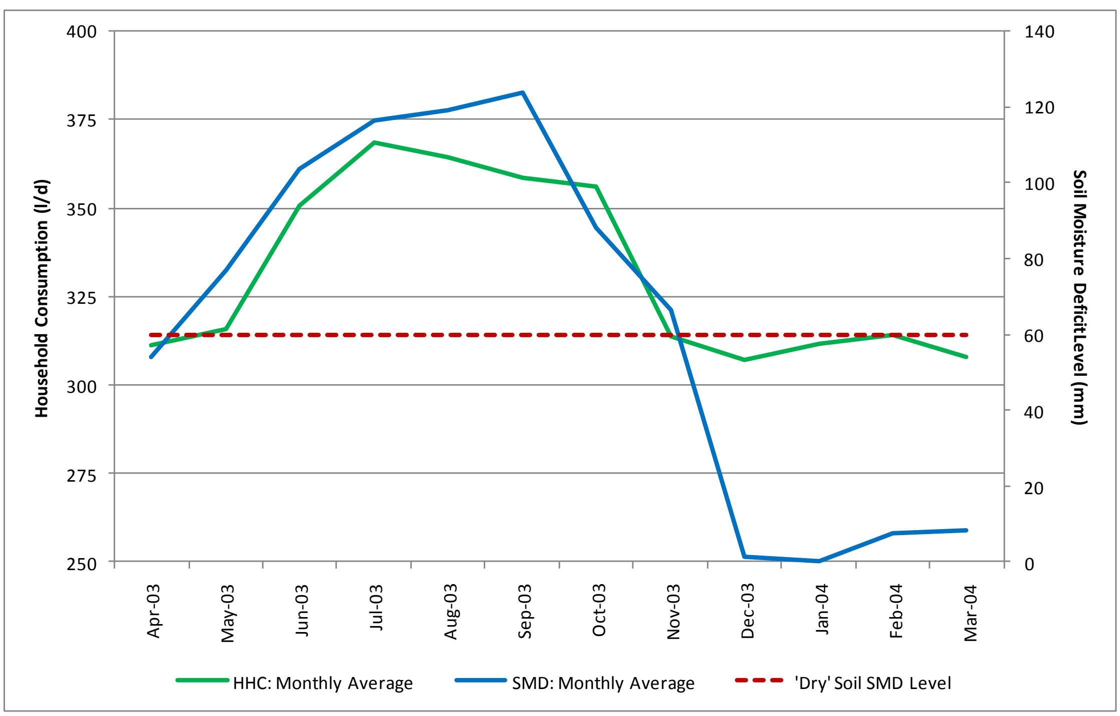
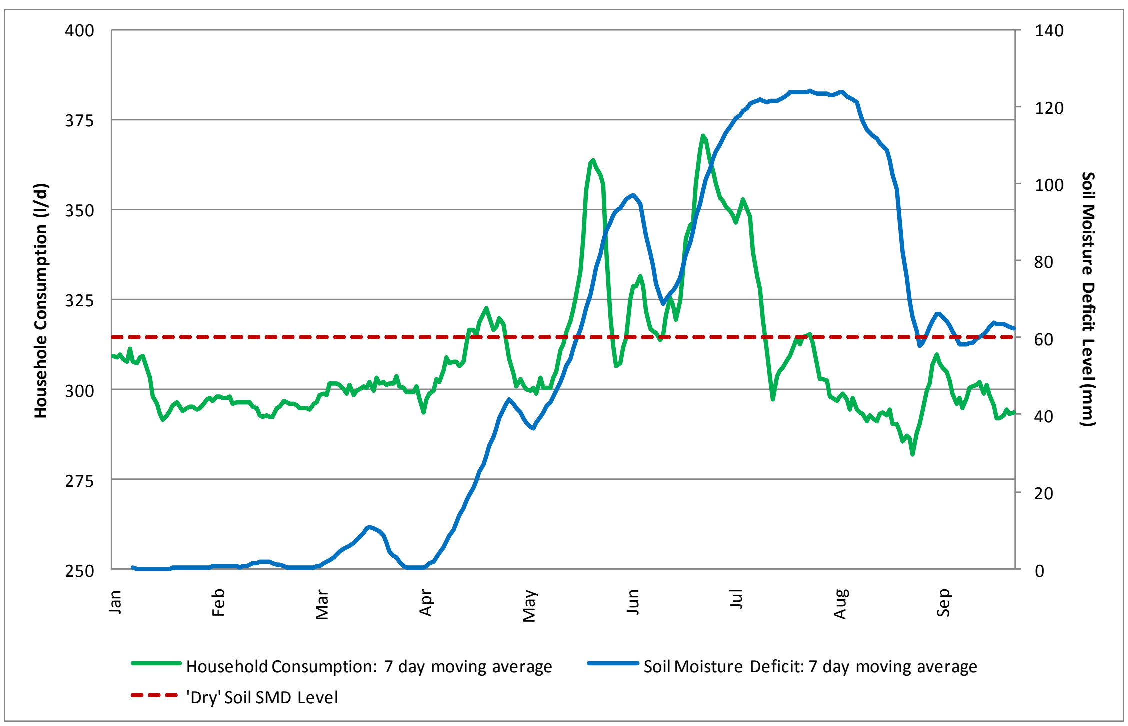


Figure 3.6 shows the daily household consumption (measured in litres per day) and SMD values during 2010 as a 7 day rolling average. Average daily household consumption during 2010 was approximately 308 litres per day. When SMD levels started to approach 60mm household demand began to increase gradually. Household consumption returned to 'normal' after SMD levelled out at around 125 mm. A similar pattern was observed in 2003-04, when household consumption began to return to normal after SMD reached a peak of around 125 mm.

Increased domestic demand can lead to immediate problems, including localised supply issues such as reduced pressure, localised loss of supply and / or burst mains resulting from over pumping. Prolonged periods of higher demand will put additional stress on our activities, further compounding the threats that already exist to these activities from climate change.

If conditions similar to or worse than those experienced during 2003 become the norm, then we can expect these kinds of issues to occur more frequently and across larger areas of our region, since similar levels of climate change are predicted in Wales and the West and East Midlands.

Figure 3.6 Monthly household consumption and Soil Moisture Deficit in 2010



3.2 Waste Water Services priority climate change risks

We identified the highest scoring climate change risks to be:

- Increased sewer flooding. The increase in winter precipitation and intense summer storms could exceed combined sewer capacity and leading to sewer flooding.
- Inundation of sewage treatment works and pumping stations from higher river levels. The increase in winter precipitation could lead to a rise in river flooding affecting sewage treatment works and sewage pumping stations.
- Reduce river consent levels and sewage treatment discharge consents.
- Impact on sludge transport routes. The increase in precipitation levels and flooding could affect local road networks affecting sludge transport routes from small sites.

We have identified the following risks with the highest scores (Table 3.2). Risks were scored out of 50. A total of 30 risks were identified, with scores ranging 2 to 20. A threshold of 12 was identified, which identified six priority risks.

Table 3.2 High priority risks for Waste Water Services

Climate Change Variable	Impact(s)	Consequence	Timescale of risk occurring	Risk Score	Pedigree Score
Higher Winter Precipitation	More local sewer flooding	Economic costs and disruption	By 2030s	20	3
More intense summer storms	More local sewer flooding	Economic costs and disruption	By 2030s	20	2
Higher Winter Precipitation	Inundation of sewage treatment works from river flooding	Asset damage	By 2030s	16	2
Higher Winter Precipitation	Inundation of sewage pumping stations from river flooding	Asset damage	By 2030s	14	2
Low Summer Precipitation.	Reduced water quality leading to river discharge consent failure.	Deoxygenated water, reduction in freshwater biodiversity	By 2030s	12	3
Higher Winter Precipitation.	Sludge transport to land is disrupted.		By 2030s	12	3

3.2.1 Sewer flooding

The key variable identified from UKCP09 was the increase in winter precipitation. Without further action, the frequency and severity of sewer flooding will gradually increase. There is also likely to be an increased likelihood of flooding from summer convective rainfall, but UKCP09 does not substantiate this. The UKCP09 modelling was based on a 25km scale which was then disaggregated to 5km for use by the UKCP09 Weather Generator. Convective rainfall occurs on a much more local scale.

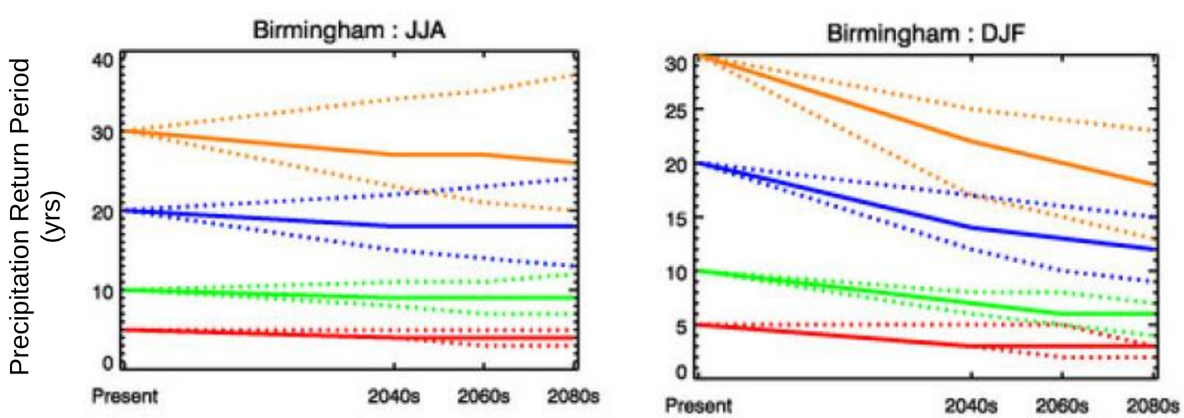
The Intergovernmental Panel on Climate Change (IPCC) has commented that there is an increased chance of intense precipitation and flooding due to the greater water-holding capacity of a warmer atmosphere. They also commented that this has already been observed and is projected to continue because in a warmer world, precipitation tends to be concentrated into more intense events, with longer periods of little precipitation in between. Therefore, intense and heavy downpours would be interspersed with longer relatively dry periods (Parry, et al., 2007).

In a report for Ofwat in July 2010, based on UKCP09, the Met Office stated "There is no clear signal for the change in frequency of summer precipitation events. The range of possible changes means that summer precipitation events could become much less frequent, or they might become much more frequent". The results for winter precipitation show a definite trend towards more frequent, higher intensity precipitation events.

Graphs from the report are reproduced below (Figure 3.7). It shows how the return frequency of summer storms (JJA) and winter storms (DJF) could change. The solid line represents the 50th percentile medium emissions scenario. The dotted lines show the 10th percentile and 90th percentile predictions.

We understand that there are proposals to carry out very high resolution climate simulations across limited areas at a 1.5km scale. We would welcome this as it would enable us to further understand the trends in convective rainfall.

Fig 3.7 Changes in summer and winter precipitation (Ofwat, 2010)



Following the publication of the UKCP09 projections in June 2009, an UKWIR project (Arkell *et al*., 2010) used the latest projections to provide a probabilistic approach. It used the UKCP09 Weather Generator at a 5km spatial resolution to disaggregate daily data down to hourly precipitation. As sewer performance is affected by peak precipitation intensity there is a need to further disaggregate precipitation down to five minutes. This highlighted some limitations of the projections for sewer flooding assessment. The Weather Generator also gave caution over interpreting long series of data in terms of return periods above 10 years. As most flooding events are caused by more extreme precipitation events this limitation needs to be recognised.

Whilst the above concerns were noted the study did produce an assessment methodology which enabled location specific (5km) data to be extracted for any combination of emissions scenario (low, medium and high), probability, time slice (2020s, 2030s, 2040s, 2050s, 2060s, 2070s and 2080s) or seasonal averaging (spring, summer, autumn, winter).

Using this methodology an analysis tool was developed to obtain uplift values using the medium emissions scenario and the 50th percentile probability for the 2030s and 2050s. Due to increased uncertainty for 2080s we did not use this time slice for this initial assessment.

We then carried out hydraulic modelling to assess the potential future performance on a sample of 12 recently constructed schemes. These schemes had been designed to current precipitation standards. Some of the schemes involved improving the conveyance capacity of the sewers, others incorporated storage. The locations of the schemes are shown on the plan below (Figure 3.8). The results gave a wide range of uplift values (see Table 3.3 below)

Whilst there is variability in the uplift values, the results are consistent with UKCP09 in that summers are expected to become drier and winters wetter. However, due to limitations with the UKCP09 predictions, these do not demonstrate the expected changes in summer convective storms which are likely to lead to more sewer flooding.

Conversely, wetter winters may result in longer duration precipitation events rather than an increase in storm intensity. Whilst this may result in flooding events it will have an effect on combined sewer overflow spill volumes, increase drain down times for attenuation tanks (on sewerage system and at sewage treatment works) and prolonging the operation of pumping stations. Performance will also be affected by higher watercourse levels inhibiting sewer outfalls. In the absence of other information we have assumed future precipitation profiles will remain constant but with uniform uplifts to represent climate change.

Figure 3.8 Hydraulic modelling scheme locations.

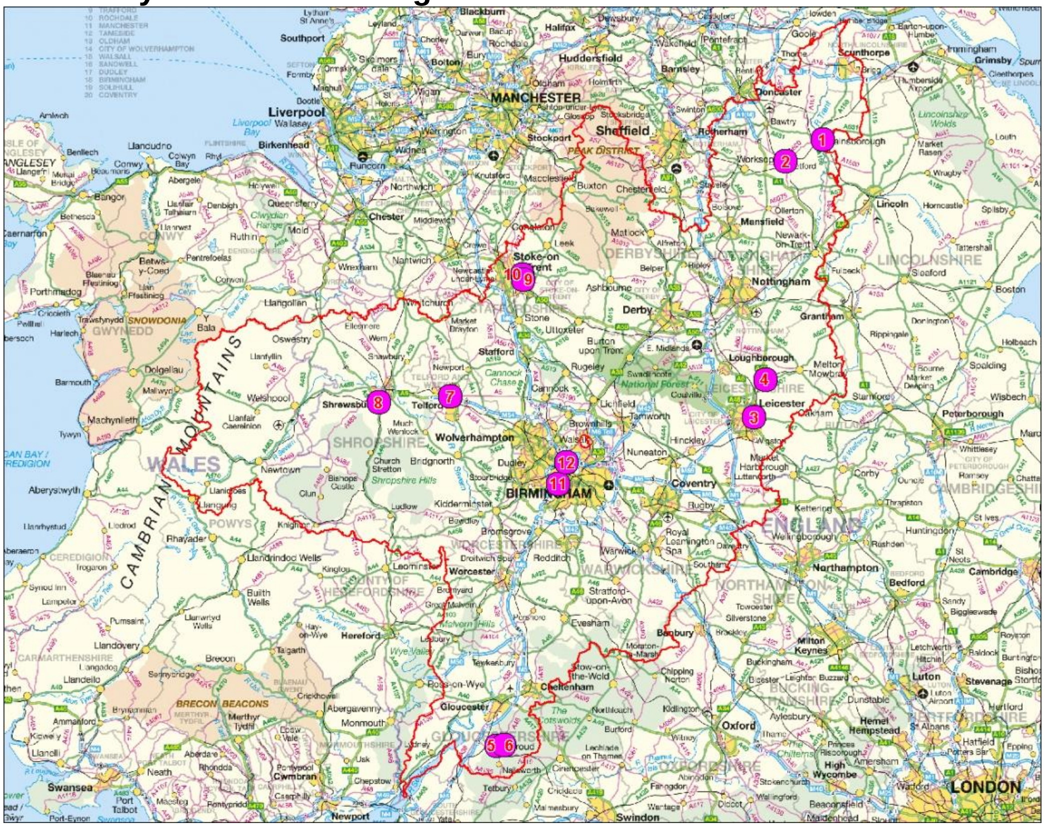


Table 3.3 Summer and winter precipitation projections.

Scheme Ref	Scheme Location	Climate change percentage precipitation uplift			
		Summer 2030	Summer 2050	Winter 2030	Winter 2050
1	Gainsborough	1.00	0.30	3.00	7.10
2	Retford	-1.50	-4.10	5.60	10.80
3	Leicester	0.60	-1.20	3.07	11.93
4	Thrussington	-2.40	-1.70	6.90	9.80
5	Stroud	-4.70	-10.40	6.40	9.00
6	Stroud	-0.50	-1.20	7.10	12.20
7	Telford	-0.60	-3.80	5.50	13.80
8	Shrewsbury	0.23	-7.20	11.10	13.30
9 & 10	Stoke	-1.83	-6.53	10.37	12.50
11	Harbourne	0.30	-4.80	6.90	9.80
12	Handsworth	-0.10	-6.90	3.80	8.40

The hydraulic modelling indicates that 8 of the 12 schemes would need further enhancement to maintain current performance. We estimate that the cost increases range from +0.6% to +41%. The total cost of the upgrades as a percentage of all 12 schemes is +12.0% (16.1% if carried out retrospectively) however the results show the wide variability of potential impact due to location site specific variables and solution types. The results are summarised below in Table 3.4

Table 3.4 Flooding impact analysis for 12 schemes.

Ref	Town	Scheme Type	CC impact?	Original Solution Cost (£000's)	Solution plus CC (£000's)	% Increase	Retrospective upgrade cost (£000's)	% Increase
1	Gainsborough	Storage	Yes	413	584	41.4	217	52.5
2	Retford	Conveyance	**No**	887	No additional enhancements required			
3	Leicester	Storage	Yes	1041	1164	11.8	165	15.9
4	Thrussington	Conveyance	**No**	171	No additional enhancements required			
5	Stroud	Storage	Yes	458	533	16.4	101	22.1
6	Stroud	Storage	Yes	529	688	30.1	201	38.0
7	Telford	Storage	Yes	496	508	2.4	53	10.7
8	Shrewsbury	Conveyance	Yes	321	323	0.6	5	1.6
9	Stoke	Storage	Yes	892	932	4.5	67	7.5
10	Stoke	Conveyance	**No**	213	No additional enhancements required			
11	Harbourne	Storage	Yes	700	906	29.4	248	35.4
12	Handsworth	Conveyance	**No**	446	No additional enhancements required			
			TOTALS	**6567**	**5638**		**1057**	

3.2.2 Inundation of sewage treatment works and pumping stations

The key climate variable from UKCP09 is the increased winter precipitation leading to high river flows. With data analysis from UKCP09 indicating the potential rise in winter precipitation by 12% and 17% in 2050 and 2080 respectively, it is likely increase to flooding incidents which affect sewage treatment works and sewage pumping stations. While the main civil engineering assets such as tanks and pipes are unlikely to be damaged, the process is likely to be temporarily disrupted and there is a specific risk of damaging electrical equipment such as panels, which are critical for continuous operation and monitoring performance of our assets.

3.2.3 Sewage treatment and discharge consents

The key climate variables affecting river flow and consent discharges from sewerage and sewage treatment works are rise in summer temperatures and a reduction in summer precipitation levels. Lower summer precipitation and higher summer temperatures, as projected by UKCP09, may lead to lower flows and higher water temperatures in rivers during the summer. These effects will make river ecology more sensitive to polluting discharges. In turn, this is likely to increase demands on us to treat sewage to higher standards.

3.2.4 Sludge transport

We rely heavily on the road network for transport of sludge from our treatment works as well as disposal of sludge to agricultural land. The key climate change variables identified are winter precipitation with the potential to increase flooding leading to disruption of the road network. It is likely that low level road networks and bridges may be inaccessible due to flooding, which is a risk to our sludge transport network with potential impact on our sludge treatment operations and sludge to land disposal route. As a result inaccessible sites particularly small sites will be at risk due to sludge storage limitations leading for process problems.

3.3 Support Services Priority Climate Change Risks

We identified five high priority risks associated with support services (Table 3.5, below). A complete Support Services risk assessment can be found in Appendix 3. Risks to power supply and supply chain are discussed in more detail. A total of 39 risks were identified, the majority of which related to staff health and safety. Scores ranged from 5 to 28 out of a possible 50.

Table 3.5. Priority risks for Support Services

Climate Change Variable	Impact	Consequence	Time Scale	Risk Score	Pedigree Score
Warmer Summer Temperatures	Failure of power infrastructure	Operational failure. Increased reliance upon back-up generators and renewable self supply	2020s	28	2
Warmer summer temperatures	Reduced raw water availability and higher temperatures. Suppliers unable to continue normal operations	Operational disruption as essential supplies not available when required	2020s	28	2
Increase in extreme events	Increased storminess and high winds causing damage to above ground telecommunications equipment	Disruption to business continuity. Operational disruption. Reduced customer service.	2020s	28	1
Warmer summer temperatures	Higher temperatures. Increased heat exhaustion of staff	Staff absence and operational disruption. Possible increased operational costs due to increased cooling requirements	2020s	26	2
Warmer summer temperatures	Higher than average temperatures and reduced reliability of telecommunications equipment	Disruption to business continuity. Operational disruption. Increased maintenance costs	2020s	25	2
Reduced summer cloud cover	Increased sunshine hours leading to increased UV exposure	Higher incidence of skin cancer affecting staff ability to work. Possibly leading to increased litigation	2020s	25	2

3.3.1 Power supply

Increased temperatures, flooding and storms may all cause damage to the electricity and natural gas transmission infrastructure. Although some 20% of our electricity supply is currently met through self supply from renewable sources some, 750 GWh are still needed from the grid. As a result we are dependent upon grid import. Failure of the transmission infrastructure, such as damage to pylons (due to high wind or snow/frost), sub stations (due to high temperature) or subterranean pipe work (due to flood damage) would result in failure of our operational systems. Only a small number of facilities sites and water treatment sites have back-up generators, although a greater number of waste water sites do have back up generators, but failure of the grid would increase pressure on these generators. As a result we would need to ensure that an adequate fuel supply is kept onsite, which, in itself, poses additional environmental and health and safety risks. It is also possible that increased temperatures may affect the operational efficiency of the energy from sludge and CHP plants, which would further affect our ability to maintain normal operations in the event of grid failure.

3.3.2 Supply chain

The projections show increased summer temperature in addition to reduced summer precipitation. The increased potential for seasonal drought and reduced runoff into the rivers (as identified in the Water Services Section 3.1) may impact certain areas of our supply chain, such as chemical production. In addition the ability of suppliers to make deliveries to our sites may be at risk due to disruption in the transport network. This is more likely to impact areas that intensively rely on external supply such as the operational areas of Support Services that work in the field, however impacts to our office based staff could include mail delivery services, to and from customers and office resource equipment deliveries.

Some of our suppliers' activities involve working outside or using equipment that is climate sensitive. With an increase in summer mean temperature and a decrease in cloud cover, we can expect an increase in UV exposure that may lead to sun stroke, as well as potentially reducing the reliability of equipment. The consequence of our suppliers not being able to continue their normal operations would put our operational performance at risk.

To ensure continuity of supply, agreements with our suppliers are in place. High risk suppliers, such as those who represent a single point of failure, have been identified and a process is in place to monitor and action risks as they arise. Where possible, we have identified mitigating actions such as identifying an alternative supplier or alternative product. In addition, the reorganisation of the Purchasing and Supply Chain team to focus on category management should lead to buyers having greater expertise in relation to their area of the market, thus giving them insight into the certain risks facing sectors and/or suppliers. At present, it is considered that the timescale for our supply chain to impact on our operations is not a significant risk as to obtain useful information from our suppliers at this time; we are therefore concentrating our business resource on contingency planning / preparedness, with the view that as and when operational parts of the business require more detail, we will investigate and analyse the most critical supplier in more detail. This could include identification of the source of supply to best minimise potential disruption.

3.4 Climate change opportunities

Assessing the impact of the climate change variables on our activities was assessed as outlined in Appendix 1. A number of positive impacts were identified and these represent opportunities. Both positive and negative impacts were numerically scored in the same way, to avoid the application of two different methodologies, and are, therefore both given a "risk rating". The opportunities are however, identified as such and the score is meant to be a reflection of the relative positive impact of the climate change variable.

3.4.1 Water Services opportunities

The key positive impacts (opportunities) of climate change on Water Services are described below. These opportunities all scored a risk rating of between 22 and 24 on the risk assessment matrix.

<u>3.4.1.1 Increased groundwater recharge</u>

A third of the drinking water we supply to our customers is abstracted from groundwater. The majority of this water is abstracted from aquifers, via boreholes. The water from these aquifers also discharges to streams and rivers, sustaining the natural environment.

Under the UKCP09 medium emissions scenario, it is projected that average winter precipitation will increase by approximately 13% across our region by the 2050s and by 18% by the 2080s. This increase in winter precipitation could lead to an increase in groundwater recharge compared with levels experienced in recent years. An increase in groundwater recharge is likely to cause a rise in groundwater levels as additional water is stored in the aquifers. This additional water may help improve the 'resource availability status' of the aquifers in the EA's CAMS assessment.

In some areas the increased groundwater recharge may make additional water resource available, allowing the development of new sites of abstraction. However, this would depend on the regulatory licensing strategy in the area. The EA's CAMS determines the water resources availability across the whole of the England and Wales, taking into consideration the state of the environment as well as existing abstractions, giving a rating of "water available", "no water available", "over licensed" or "over abstracted". Where the areas are designated as being over licensed or over abstracted, no new licences will be granted or if they are, they are subject to strict conditions around when abstractions can occur. Increased groundwater recharge could help to improve the CAMS status across our region, opening up new areas where abstractions could be developed. However, if the assessment does not improve sufficiently as a result of the increased groundwater recharge we would be unable to take advantage of the increased resource.

<u>3.4.1.2 Reduced leakage</u>

Severn Trent Water operate some 46,000 km of water pipe network, and at the current rate of asset replacement, the pipe network is slowly deteriorating (an estimated 16 Ml/d of leakage appears every year due to this aging). UKCP09 shows that the average winter temperature is expected to rise by around 2°C by the 2050s, with a further 1°C rise by the 2080s, with the minimum winter temperature rising by around 2.5°C by the 2050s and about 3.5°C by the 2080s. If this increase in winter temperature happens as predicted, the change in climate would have a positive effect by reducing leakage in our region. A study conducted by UKWIR (2007) investigating the management of seasonal leakage across the UK found that the severity of the peak in leakage outbreaks during the winter is dependent on the temperature, the colder the winter period the higher the winter leakage peak. Additionally, the occurrence of three to four consecutive frost days increases the likelihood of bursts occurring.

Reduced leakage would have a number of other positive implications:

- Winter "peakiness" in the leakage profile would be reduced. This would allow resources to be spread more evenly throughout the year.
- Reduced spending on leakage repair.
- Energy consumption would be reduced as less pumping would be required.
- The need for capital expenditure to improve levels of service would be reduced.
- Leakage levels could be driven down further at an economic rate.

3.4.1.3 Increased river flows and winter raw water storage

Under the UKCP09 medium emissions scenarios, it is projected that average winter precipitation will increase. This is likely to lead to increased runoff, which in turn will increase river flows during the winter months. The projected change in precipitation could benefit the environment (for example higher river flows will help dilute pollutants such as nitrates and phosphates which are commonly used in fertilisers that run off fields into watercourses) as well as providing an opportunity for the Severn Trent Water to optimise winter storage and help alleviate flooding by maximising bank side storage. Higher river flows would also aid the recharge of our pumped storage reservoirs which are refilled by water pumped from the rivers during the winter months. The level of the river determines how much water we are able to abstract and store in our "pumped storage" reservoirs – if the river level is low, then abstractions are restricted to prevent the rivers dropping below a sustainable level. More physical resource would be available to abstract, treat and put into supply.

In addition to public water supply provision, in 2009/10 we produced 5.9 GWh of electricity from hydro-electric power (HEP) generation, which was 3% of the total electricity we self-generated. Our HEP production is primarily derived from the river compensation releases we are required to make from the impounding reservoirs at Clywedog, Ladybower and Vyrnwy. With further investment, the projected increases in winter precipitation could enable us to enhance HEP generation at our existing sites and to utilise some of our other reservoirs for HEP generation, particularly where we are already providing compensation releases to support river flows. In order to make use of our other reservoirs, or increase the generation potential at existing HEP sites, investment would be required to install pumps, generators and other infrastructure.

The benefit gained by the increase in winter mean precipitation could, however, be limited by the accompanying change in potential evapotranspiration which would result from increased temperatures and changes in land use (agricultural practices are likely to change as farmers adapt to the changing climate). Therefore the overall impact on river flows may be less than anticipated.

If river flows do increase sufficiently for us to increase abstractions from existing sources or to develop new sources in areas where river flows have increased, we would need to consider the regulatory licensing strategy as this may prevent use of additional resources if they become available.

3.4.2 Waste Water Services opportunities

The Flood and Water Management Act 2010 clarifies responsibility for managing surface water and places much of the responsibility with local authorities. For the first time, this provides the opportunity to manage surface water holistically and provides a clear framework for the ownership and maintenance of sustainable drainage systems.

We have starting to work with local authorities to ensure that they understand the affect that excess surface water can have on our assets and encourage them to minimise it. This coordinated approach could be significant in supporting efforts to reduce the effects of climate change on our assets. (See Chapter 7, 8 and 9 on stakeholders, interdependencies and barriers to adaptation)

Nitrification (the biological conversion of ammonia to nitrate) is especially sensitive to temperature, with reaction rates substantially reduced at lower temperatures. At present, sewage treatment works are designed to meet the required effluent quality at minimum sewage temperatures of 8°C. Warmer temperatures would allow smaller new works to be built (saving capital expenditure) and parts of the plant could be taken out of service (saving Operational expenditure) at existing works. This benefit may, however, be offset to some extent because oxygen transfer efficiency is reduced as temperature increases.

Warmer temperatures could allow us to change the type of secondary treatment process we operate. Rather than using conventional, energy intensive, aerobic treatment processes used at the moment, we may be able to install anaerobic processes, which require no oxygen and produce biogas that can be used to generate renewable power, offering substantial energy savings. At present anaerobic treatment is only proven for domestic sewage treatment at sewage temperatures seen in tropical climates. However warmer weather and on-going R&D to widen the applicability of anaerobic treatment could lead to wider implementation of this technology.

In the sludge treatment process, we will experience a small reduction in heat loss during heat transfer from the CHP engines to the digesters, resulting in an improvement in energy efficiency in the process.

3.4.3 Support services opportunities

In addition to the threats that have been indentified using the risk assessment measurements we have been able to identify two opportunities that climate change could offer Severn Trent Water.

<u>3.4.3.1 Reduced energy requirement for heating</u>

One of the key things that can be taken from the data that have been analysed for this assessment is that the temperature is likely to increase in both summer and winter. This allows us to assume that there will be less of a requirement to heat our sites, thus reducing the energy used by our sites and our carbon emissions. This opportunity will have an impact all year round as there are likely to be fewer cool days in the summer and winter.

<u>3.4.3.2 Reduced winter travel disruption</u>

If projections for winter conditions are correct, there will be less snow fall. This represents a significant opportunity for the business as we escape the hugely detrimental effects periods of snow and ice can have on our transport infrastructure.

Examining the areas that this affects we can determine that this has the potential to reduce the number of working days lost due to weather related absence as well as not being able to reach customers to complete work (meter reading/installation). Between December 2009 and February 2010 Severn Trent Water missed 636 appointments with customers due to snow. Warmer conditions, would therefore lead to an improvements in service.

In addition to this we would be able to ensure the access to the operational sites and maintain consistent logistical movement. Moreover, as sites would be clear of ice and snow there is potential to reduce lost time incidents incurred as a result of weather related accidents.

4. Uncertainties and assumptions in the data

4.1 Uncertainty in the data

Throughout this risk assessment process we have identified several areas of uncertainty, chiefly associated with how the UKCP09 data should be applied in terms of quantifying the impact of climate change on our activities. In some areas, where quantitative data is limited, our risk assessment has had to be based on expert opinion. In other areas we have been able to refer to detailed technical assessments.

For example, modelling the impacts of climate change is a well established process in our water resources planning activities. Previous assessments of the impact of climate change on our water resources have followed the best practice methodology available at the time. In our most recent Final Water Resources Management Plan we followed the EA's Water Resources Planning Guidelines (November 2008) in order to quantify the impact of climate change on our surface water resources (reservoirs and rivers).

These methods have allowed us to assess the potential impact of climate change on our activities by the 2020s and showed that both our surface water and groundwater resources are likely to be affected by the end of the planning period. Uncertainty also remains as to how severe these impacts may be.

The UKCP09 data and tools are so wide ranging it is difficult to know which is the best method / tool / dataset to use. For example, we do not know how long the predicted extreme events will last for. We have begun assessing the impacts of climate change based on UKCP09 projections, but further analysis is required and will be carried out in the coming years. A joint EA / UK Water Industry Research (UKWIR) project is currently underway, which will provide recommendations for the best practice methodology (and Industry Standard) for how to apply UKCP09 tools and data in our assessment of the impact of climate change on our water resources.

To account for the uncertainty around the risks and opportunities we have identified, we have incorporated a likelihood scoring within our risk assessment, meaning that uncertainty forms an integral part of our overall risk rating. Additionally we have applied a pedigree scoring, based on HR Wallingford's methodology applied to the UKCCRA to demonstrate the level of evidence available and the reliability. This pedigree scoring system is shown in Appendix 1. It is likely that the pedigree scorings we have assigned will improve as data become more accurate and as further evidence becomes available.

Uncertainty also remains in relation to the way the in which regulatory powers such as the EA and Ofwat will operate in the future. It is likely their policies will change in response to the changing climate projections. We need to ensure stakeholder engagement continues and that we actively work with the regulators in developing sustainable policies and to influence future European Directives.

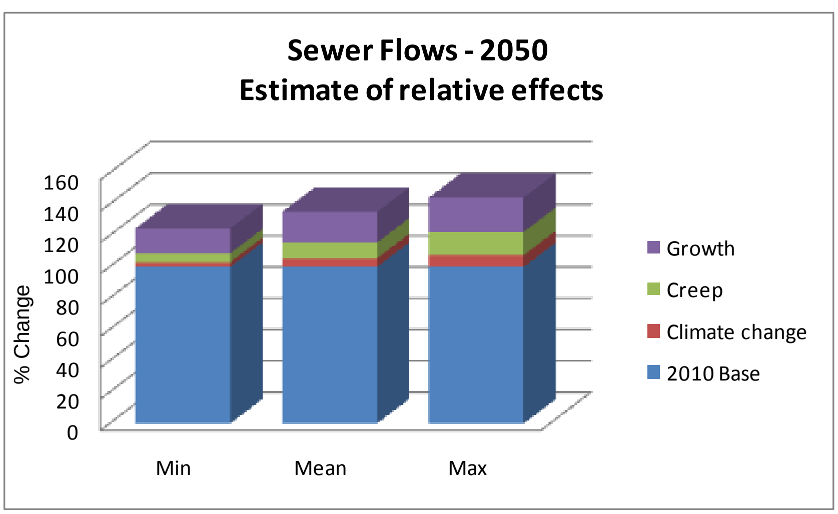
4.1.1 Uncertainties associated with sewer flooding

When using the UKWIR tool, to develop potential precipitation uplift values (Section 3.2.1), we observed a wide variation in results for locations which are geographically similar. In line with the UKCP09 projections, the results show a reduction in summer precipitation. There is, however, likely to be an increased likelihood of flooding from short duration summer convective precipitation, but the UKCP09 does not substantiate this and is not properly understood.

The UKWIR project also commented that whilst there were uncertainties over the potential impact of climate change, this was only one of several influences on future sewer performance summarised below:
<u>Sewer modelling</u>: Industry guidance (WaPUG, 2002) suggests that storm flow verification should be in the range -15% to +25%.
<u>Emissions scenarios</u>: +/-5 to 7 percentage variance on climate change uplift values
<u>Natural variability</u>: -5 to +5 percentage points climate change uplift values in winter and -6 to +7 percentage points in summer
<u>Climate change uncertainty</u>: -4 to +3 percentage points climate change uplift values in winter and -6 to +8 percentage points in summer
<u>Weather Generator seed selection</u>:+/-2 to 3 percentage points climate change uplift values

Climate change is just one significant factor affecting the frequency and severity of sewer flooding. We estimate that development within the catchments (growth) and the tendency of property owners to pave over gardens, referred to as creep, may have a more significant effect. We have estimated the relative scale of these effects which are shown in the following graph (Figure 4.1)

Figure 4.1 Sewer Flows 2050: Estimate of relative effects



These estimates do not take into account any reduction in flows achieved through our strategy of surface water separation (see Section 5.1.2).

4.1.2 Uncertainties in sewage treatment works and discharge consents

With rising temperatures and low summer precipitation, there is EA river flow data to evaluate the effect of river levels and consent changes are currently under review. We are modelling the effects of sewage treatment discharges on river quality with SIMCAT simulation software and using river monitoring and flow data , however data linkage with climate change is not available. Furthermore, we also need consider other external factors e.g. commercial discharges, which can alter river consent levels and impact our discharge consents.

4.2. Assumptions

We have assumed that the UKCP09 data are the most up to date and constitute the best available evidence. We have also had to assume that we will continue to operate within the current financial and regulatory regime.

5. Managing climate change risks

Managing the impacts of climate change is already built into our 25 year strategic plan and Water Resource Management Plan. In this section we outline our strategic plans in place that will secure water and waste water services to our customers over the next 25 years. Those plans have considered a wide range of risks to our ability to supply water and treat waste water, including climate change risks. As a result, we are already undertaking a significant capital investment programme to reduce these risks, and details of our current strategy.

Between 2010-2015 (AMP5) we will:

- Invest £1,000m to provide a continuous supply of quality water, focusing on the resilience of the network and treatment works, leakage reduction, water efficiency, flood protection, improved monitoring, distribution mains and in the treatment process itself.
- Invest £1,200m in waste water treatment, on resolving internal and external sewer flooding, sewage treatment standards and flood prevention.

Due to the way the water industry is funded, under the Periodic Review process, there is considerable risk in to committing to plans beyond 20145/15. In preparing this report, we have worked with UKCIP to derive a framework that would provide a consistent and transparent process for identifying the most holistic, flexible and low-carbon solutions. Following this methodology, as outlined in Appendix 1 this Chapter therefore also explain how the outputs from our climate change risk assessment have further informed our understanding of the key risks and how they will influence our next round of strategic plans.

5.1 Managing Severn Trent Water's climate change risks

5.1.1 Severn Trent Water's AMP5 water supply resilience investment strategy

The flooding incident at Mythe in 2007 highlighted the inherent risks within our water supply network. As a result we have re-assessed the adequacy and resilience of our network to accommodate failure of key assets and identified where mitigation alone cannot bring the current risk level below an acceptable level.

Our own customer research, as well as that from the Consumer Council for Water (CCW) reinforced the view that such an incident should never be allowed to happen again, either in the Gloucester area or elsewhere. The conclusion from customer focus groups was that "The extra expenditure planned on resilience, where 1.4 million customers would be provided with alternative sources of water, was fully supported" (Accent report on qualitative research). We have based our latest investment plans on the very high priority which customers give to ensuring a safe and reliable water supply.

Our current plans are based on improving the resilience of our strategic network and reducing the risks to customers of losing their water supply to below an acceptable threshold. The practical and unique lessons we have learned as a result of the Mythe incident underpin our plans, along with the recommendations set out in the Pitt report; Learning lessons from the 2007 floods.[12]

Together, our WRMP and our AMP5 Business Plan form complementary strategies to reduce the risk of a supply failure to customers over the next 25 years, either due to a resource shortfall or catastrophic supply failure.

In line with best practice guidance, our AMP5 plan has used a risk based approach for assessing investment to enhance our customers' security of supply. As a result, we plan to invest £202m of capital expenditure to increase security of supply to 2.94m customers. Table 5.1 shows the type and number of schemes to be delivered over the course of AMP 5.

Table 5.1 AMP 5 delivery in Water Services

Type	**No. of Schemes**
Water treatment works & strategic grid failure	14
Loss of critical boreholes	8
Flood protection	7
Power failure	260
Single points of failure	1
Reduce risks to isolated communities	9
Total	**295**

We have carried out risk assessments on:

- The resilience of water treatment works and our strategic grid network
- The resilience of boreholes
- Single points of failure within our water treatment works
- Fluvial flood risk of our key assets
- Power loss risk of our key assets

We have adopted a principle of 'unacceptable consequence' as a risk management objective in cases where mitigation cannot bring the number of customers affected below a threshold level of 20,000 customers, which is the limit of our alternative supplies capability.

[12] Sir Michael Pitt was asked by Government to conduct an independent review of the flooding emergency that took place in June and July 2007. Interim conclusions were published in December 2007. The final report was published in June 2008.

We have developed and applied a methodology to assess both the likelihood and consequence of treatment works or borehole failure. This methodology links to our non-infrastructure capital maintenance work and includes operational, pollution and security risks and shows how our resilience and capital maintenance works interact.

5.1.2 Severn Trent Water's AMP5 waste water investment strategy

We have already taken the impact of climate change into account in our business plan to 2014/15 and have incorporated changes to our new assets to cope with potential uncertainties.

5.1.2.1 Sewer flooding

Sewerage systems are designed to cope with storm events with a particular likelihood of recurrence. We currently design our systems so that the likelihood of flooding a building is not greater than 2.5% in any year. The industry standard is 3.33%. We estimate that precipitation intensities would need to increase by 7% to erode this difference. Based on UKCP09 data (see Appendix 2) we estimate that the system will be resilient against peak winter precipitation until around the 2030s.

Our initial assessments indicate that it is not practical to apply a standard approach to mitigate against climate change and supports a move towards a risk-based approach rather than fixed design standards. This approach uses overland flow path modelling and takes into account the consequences of the flooding as well as the likelihood. It also indicates that conveyance solutions appear to be less susceptible to the impacts of climate change compared to storage options.

Building on our earlier Drainage Area Plan programme, we are now developing Sewerage Management Plans across our region. Using the latest hydraulic modelling techniques, these will give us valuable information on the risks of sewer flooding. Using these we will evaluate how risks are likely to change from factors including climate change. We are sharing the results with our stakeholders.

We are also considering whether to modify our approach to conventional sewerage design and continue to design schemes to a likelihood of not greater that 2.5% as an interim measure. We are considering which parameters to use but we will work with stakeholders and consult with Ofwat before confirming our approach.

5.1.2.2 Inundation of sewage treatment works and sewage pumping stations

As well as the collaborative work described above and in order to combat inundation of sewage treatment works from river flooding, we have modified our design standards to enable our works to withstand 1 in 100 year flood events.

We are also raising the level of electrical control panels at some sites or providing localised flood defences where they are at risk of inundation.

5.1.2.3 Sewage treatment & discharge consents

To maintain the quality of the watercourse it may be necessary to treat the effluent to a higher standard. This will generally involve the construction of more assets and the use of more energy and chemicals to run them. To ensure that we do this only where absolutely necessary, we are collaborating with the EA to develop ways to balance carbon emissions with river ecology.

As part of the project, we have carried out trials at Coleshill sewage treatment works (an activated sludge plant) to test whether we can operate our plant dynamically in relation to river flow, meeting the standards that the river and ecology require whilst using less energy, thus reducing carbon emissions. As an example, we would like to understand if we treat to tighter ammonia limits when the river flow is low and more relaxed limits when the flow is high.

To reduce our carbon emissions and to combat rising energy prices, we are seeking to be more energy efficient and invest in replacing inefficient process units such as pump motors and activated sludge plant diffusers. This has been a key focus in AMP4 and will continue to be.

In order to combat inundation of sewage treatment works from river flooding, we have modified our design standards to enable our sewage treatment works to withstand 1 in 100 year flood events. Furthermore, flood defences at two large sites were proposed to reduce the risk of power loss and pollution.

5.1.2.4 Energy from sludge

Our combined heat and power (CHP) plant has a capacity of 30MW, in 2009/10 we generated 175.8GWh of energy from sludge, accounting for 20% of our total company annual consumption. This energy is largely utilised by our own operational sites. This has helped us lower our operating costs and provide protection against volatility in the energy market. We have made further internally cost beneficial investment in CHP technology and improving site efficiency to help combat rising energy prices and energy supply. We are progressing towards achieving our company target of generating 30% electricity from renewable sources by 2013[13].

5.1.3. Managing the effect of climate change on Support Services

To ensure business continuity we already have a number of contingency plans in place to ensure continuity of supplies, maintain communication and to maintain power supply to critical assets. In addition to the construction of Severn Trent Centre we will deliver a number of schemes over AMP 5 which improve the

[13] 30% is an ST Plc target and includes renewable generation (wind, energy crop and energy from waste) by the non-regulated business

quality of our working environment. This includes the refurbishment of our regional offices at Redditch, Shelton and Raynesway.

5.2 Future actions to manage the effect of climate change

Throughout the risk assessment process, we worked with our business experts to capture a wide variety of mitigation and adaptation options. These options ranged from providing new capital assets to changing our operational practices.

We have shown in Section 3 that one of the highest ranking risks identified were the effects of low summer precipitation and high summer temperatures on river and groundwater ecology. The consequence of these risks would be to restrict our ability to abstract water during summer periods. During our review of these risks, a wide range of potential adaptation responses were identified to help mitigate the climate change impacts (See Appendix 4).

The costs, benefits and environmental impacts of each of these options would need to be assessed to derive the most sustainable and cost effective adaptation response. Due to the number of potential options, however, a detailed cost / benefit assessment of all of the options would be costly and complex. Therefore, we have developed a two stage process which will screen out the least feasible and sustainable options before carrying out a detailed cost / benefit assessment on the more feasible options.

Following the methodology outlined in Appendix 1 we have begun to analyse the available options, allowing us to focus the detailed cost / benefit assessment on the most feasible (see Appendix 4 for examples). Using this process we will be able to identify which options should be taken forward for a more detailed engineering appraisal. Those options with the best scores will have a full cost / benefit assessment carried out, while those with the worst scores will not be considered in more detail when our long term investment strategy is next updated.

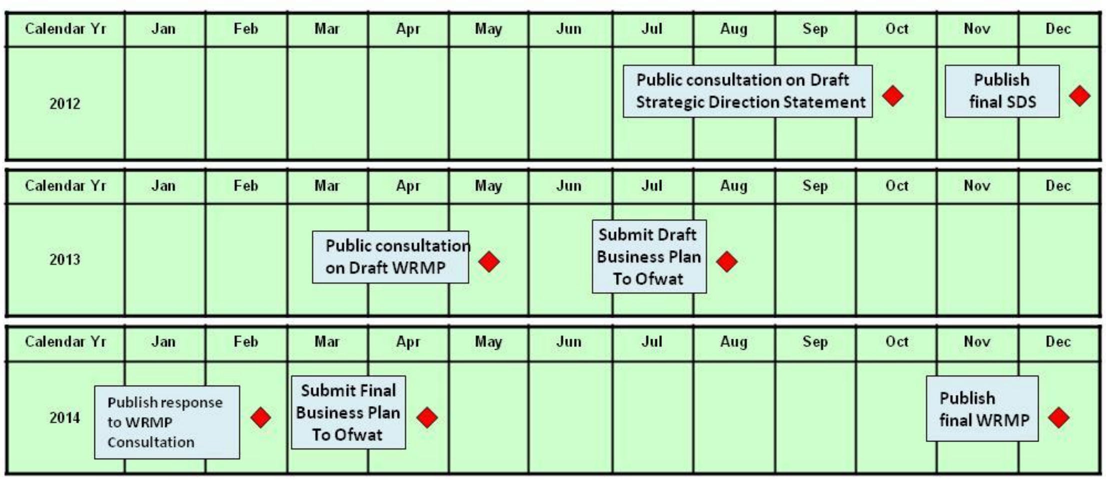
6. Integration into business as usual

As noted in the Chapters above, we are in the process of implementing a number of schemes as part of our AMP 5 business plan which will help us adapt to climate change. In addition we have developed a robust methodology to help us identify and appraise additional options to mitigate our priority climate change risks. We will embed this process into our PR14 plans.

The process of regularly reviewing the long term risks around water supply and updating our investment plans is well established within the water industry. Ofwat and the EA require the water companies of England and Wales to submit updated Business Plans and Water Resources Management Plans every five years. These documents set out the long term risks, issues and uncertainties facing our water supply activities, and our investment strategy to ensure a sustainable and continuous supply of water to our customers.

We have a rolling five year business planning process. Under the Price Review Process we submitted the plan to Ofwat in March 2009 to cover the period to 2015. Our current Water Resources Management Plan was published in 2010 and sets out our strategy for securing sustainable water supplies for the next 25 years. The outputs of this climate change risk assessment will form the basis of both of these plans, when they are updated for re-submission in 2014. The timeline for preparing, consulting on and submitting these plans is set out below (Figure 6.1).

Figure 6.1 Timeline for Price Review 2014



The process we have been through in producing this climate change risk assessment has helped us to reassess how we incorporate climate change related risks into our business planning. In responding to the Direction we have developed a more rigorous and detailed climate change risk assessment and options appraisal process. This allows us to identify the key climate related risks to our supply activities along with the causes and consequences of these risks. The work we have done with UKCIP has also given us a new set of criteria that we will use to assess the sustainability and feasibility of our adaptation and mitigation options.

We are now embedding the outputs from this climate change risk assessment and adaptation into our PR14 Business Plan, to cover the period 2015/16-2019/20, and WRMP preparation. We will use the UKCP09 climate change scenarios to test the sensitivity of our water resources, supply network and waste water treatment processes to the range of climate variables. We will also use the process we developed with UKCIP for assessing the adaptation options that get promoted in our 2014 Final Business Plan.

6.1 Ongoing monitoring

Our asset investment plans are based on the most up to date available evidence and best practice methodologies available at the time. We monitor and report on progress against our asset investment plans each year and we publish the results in our annual June Return submission and the Water Resources Management Plan Annual Review[14].

These annual publications report on what progress we have made with implementing our investment plans, and give details of our service delivery performance in the year. Our performance against many of the issues that are included in our climate change risk assessment water service risk assessment is included in our annual reports. For example, we report annually on our performance in areas such as:

- The total amount of water abstracted from the environment
- Total leakage and leakage trends
- Number of properties experiencing low pressure problems
- Number of drinking water quality failures
- Number of properties experiencing an unplanned loss of supply
- Number of internal sewer flooding incidents
- Number of pollution incidents
- Quality of sewage treatment discharges

We continually monitor our water and waste water service delivery performance and seek to understand when and why our performance may have changed. We monitor the number of blockages on the sewerage system and the number of properties which suffer from sewer flooding. We also monitor the number of complaints we receive about odour and other nuisance from our sewage treatment works and other assets. These are key metrics which we use in conjunction with deterioration models to develop our rolling five year investment plans.

[14] Our annual June Return and Water Resources Management Plan Annual Review can be found on Severn Trent Water's website at http://www.stwater.co.uk/

We routinely investigate how the weather events experienced in the reporting year may have affected performance. It is through this kind of analysis, for example, that we have been able to determine that 2006 was a year of extremely high peak demand for water, and that the demand increase was driven by a record high temperature.

The data reported in our annual June Return and Water Resources Management Plan Annual Review, forms a significant part of the evidence base we use when preparing our asset investment plans. Because of our established annual reporting process, we have a lengthy time series of service performance data from which we can determine trends. We will continue to add to that time series as we report on progress with implementing our AMP5 investment plan between 2010-11 and 2014-15.

We will reappraise the effects of our programme on an ongoing basis. At each periodic review, we will re-examine our levels of investment, and the effectiveness of our strategy to ensure that they are still appropriate. We will take into account the latest information on climate change as and when it emerges.

Wherever possible we aim to improve the resilience of our assets by avoiding the construction of new assets and to work with the natural processes and with other stakeholders to minimise the consequences of climate change. We recognise that this will not be possible in every case. Where we need to construct new assets, we will use the best available information so that they are likely to remain sufficiently resilient to serve the needs of our customers into the future without locking us in to any particular pathway.

7. Stakeholder engagement

Climate change has the potential to affect every element of our operations. Minimising our contribution to climate change and effectively adapting to the effects, requires not only us, but also our stakeholders to understand the risks it presents and take appropriate action in response to those risks.

As a provider of essential services, we place a high priority on stakeholder engagement and the value it brings. For example:

- Understanding and responding to our customers' priorities to ensure we best meet their needs
- Working with organisations, authorities and representative bodies whose services and resources affect our operations, and who in turn our operations affect
- Contributing to the development of government policies and regulatory approaches to ensure a framework exists that facilitates the delivery of the best possible outcomes for our customers, investors and the environment.

In the specific case of climate change adaptation, we engage with our stakeholders to ensure:

- We fully understand the risks climate change presents by using the best available information and the most appropriate methodology to assess climate change risks
- We communicate the priority risks to those who may be affected by them
- We work with relevant organisations to find the best approach to manage the priority risks
- We understand the dependencies and interdependencies in managing climate change

In preparing our climate change risk assessments we have:

- Drawn on the extensive discussions, consultations and research that we used to develop our future plans including our Strategic Direction Statement, Water Resources Management Plan and PR09 Business Plan (see Appendix 5)
- Sought to raise awareness of the risk assessment, secure comments and contributions as we carried it out, and discuss emerging issues as it neared completion.
- Revisited our stakeholder analysis in the light of the outcome of the risk assessment to identify the need and opportunity for future consultation and collaborate working, particularly as we develop our business and investment plans for the 2015-20 regulatory period.

7.1 Engagement for this risk assessment

We had three priority objectives for our engagement in relation to the climate change risk assessment:

- Ensure we take a robust and effective approach to carrying out the assessment which is informed of the appropriate expertise
- Raise awareness of risks identified, dependencies and issues that exist, and promote a coordinated approach to addressing them
- Establish how the risks identified will need to be incorporated in our engagement as we develop our plans for future operations and investment

Appendix 5 contains more detail on how we identified key stakeholders in the climate change risk assessment process.

7.1.1 Defra, Cranfield, UKCIP and the water industry

In order to ensure we took the best informed approach to carrying out this assessment, and did so in the context of the risks identified by other water and wastewater companies, we discussed our approach and emerging findings with:

- Defra's Climate Change Adaptation team
- Ofwat
- Water UK Climate Change Network
- UK Climate Impacts Programme.

Through Water UK we have had ongoing liaison with Defra's Water Availability and Quality Team and the Adapting to Climate Change Team and with Cranfield University. On 4 November 2010 we organised a site visit to the Mythe Water Treatment Works to demonstrate the scale and practical aspects of the provisions of water and sewerage services, and to aid interpretation of the sector's response to the Adaptation Reporting Power. The visit also gave us the opportunity to show the extent to which the works were affected by the severe flooding events in 2007 and the subsequent investment undertaken to increase resilience.

Through the Water UK Climate Change Network we have had the opportunity to review our methodology, findings and thinking on adapting to climate change with other water and wastewater and water only companies. This enabled us to identify common areas of uncertainty, barriers and interdependencies as well as possible collaborative methods to overcome these.

7.1.2 Ofwat

It is important that the framework for economic regulation of the industry facilitates water companies taking an effective and proportionate response to climate change.

On 12 November 2010, we met with the Ofwat's Climate Change Team to discuss the provisional findings of our risk assessment and how it, and the implications for our future operations, could be approached at the next price review (PR14). The aim of this session was to provide Ofwat with an overview of our work to date and to understand further how Ofwat will approach climate change adaptation in the future. It was agreed that climate change adaptation would be a key consideration for PR14 and that the sector as a whole would need to work together to ensure it is fully integrated into the process.

7.1.3 Environment Agency

One of the key dependencies we identified as part of our assessment was the EA's future approach to regulation, particularly with regards to abstraction licensing and discharge consents. Through Water UK, the sector was presented with an overview of the EA's approach to the Reporting Power. We also met with water and climate change teams in the Midlands area to raise awareness of our work under the Adaptation Reporting Power on 9 December 2010 and understand their climate change related risks and options.

7.1.4 Regional Quadripartite Group

The risks climate change presents, and the action we take to respond to them, can not be considered in isolation of other issues. For example, are customers willing to pay for a secure supply when faced with greater risk? Does the regulatory framework incentivise the right behaviours from companies to address those risks?

Every six months we take part in a regional 'Quadripartite Group meeting led by the water industry's customer representative body, CCWater, and comprising EA's, Drinking Water Inspectorate (DWI), Natural England and Ofwat. We use this forum to encourage cross-regulatory discussion about adaptation both whilst we were carrying out our assessment (July 2010) and once complete (January 2011).

7.1.5 Regional Climate Change Partnerships

In order to encourage further cross-sector discussion, and in particular build an additional platform for collaborative working with local authorities, we opened dialogue with the East and West Midlands Regional Climate Change Partnerships.

The majority of local authorities in our area have committed to achieving National Indicator 188 Planning to Adapt to Climate Change (NI188) and the action we take to adapt is likely to impact on their plans.

<u>7.1.5.1 Climate East Midlands</u>

On 8 October 2010 we met with the East Midlands Regional Climate Change Partnership, Climate East Midlands Planning to Adapt team. This group is made up of representatives from the EA, Natural England, UKCIP and the climate change managers/project officers from the East Midlands county and city councils. This was an initial discussion to raise awareness and to present an overview of the work we have conducted to date through our Business Plan, SDS and WRMP and to review our use of UKCP09 and the methodology used and the findings of our climate change risk assessment.

We also used this session to gain a better understanding of the work that the Councils have done in working towards meeting their requirements under NI188, the Local Area Agreement for Planning to Adapt to Climate Change. In addition, we used this as an opportunity to identify other key groups such as town planners, engineers, surface water managers and emergency planners whose work may either be dependent upon our actions or whose actions may affect our operations. As a result, through Climate East Midlands Climate Change Weeks[15], we were able to organise a second, more in depth workshop on 11 November 2010.

The second workshop was open to all East Midlands city, county and district/borough councils and any other interested parties. Twenty-four delegates attended the workshop. The objectives of the workshop were to:

1) Raise awareness within public sector bodies of the work that we are currently undertaking on climate change
2) To give public sector bodies the opportunity to comment on the findings from our climate change risk assessment and options identified to manage our priority risks
3) To understand the interdependencies with our key stakeholders within the East Midlands in relation to climate change
4) To give public sector bodies the opportunity to discuss how their operations may be affected by our operations and decisions in relation to climate change.

Te details of this engagement workshop are presented in Appendix 5.

7.1.5.2 Sustainability West Midlands

On the 6th October 2010 we met with Sustainability West Midlands. In attendance at this meeting were representatives from Natural England, the EA, Ofwat, Birmingham city council, Worcestershire county council and academics from Universities within the West Midlands (see Appendix 5 for agenda). During this session we presented the findings from our use of UKCP09 and the methodology used and the findings of our climate change risk assessment. This stimulated good discussion over issues such as abstraction, sustainable catchment management and the involvement of local communities. The group had no issues with either our risk assessment methodology or its outputs. Through this group we have also had an input into the West Midlands risk assessment under the UKCCRA.

7.2 Future engagement

As we note above, we already engage with stakeholders on issues such as climate change adaptation as part of our routine planning activities. Due to time constraints we have not been able to make contact with all of our stakeholders.

[15] A series of workshops for East Midlands public sector bodies to aid them on climate change mitigation and adaptation between 1st and 12th November 2010.

We will seek to engage with those stakeholders once the report is submitted and published. Those include the National Farmers Union (NFU) and its members, the Welsh Assembly Government (WAG), Countryside Council for Wales and energy/gas transmitters/distributers. We will also revisit our approach to stakeholder engagement in light of the climate change risks identified as part of this reporting process. We have already assessed stakeholders against the climate change risks (see Appendix 5) and will continue to revisit our engagement plans to ensure ongoing communication and promote collaborative working.

7.2.1 Communicating the outcome of this risk assessment

Once Defra has approved the report we will make it publically available through our website. We will also proactively disseminate the report to the key stakeholders we have identified above with the intention of encouraging further awareness and commitment to mitigating the risks identified.

7.2.2 Working with our stakeholders as we develop our adaptation plans

In 2015 we will enter into a new investment period. We are already working on our next business plan, reviewing our Strategic Directive Statement and updating our Water Resources Management Plan. This risk assessment will be embedded in the development of those plans.

As we develop options to adapt to climate change we will consult with stakeholders who will be affected by them, such as customers. We will engage with those who can support the achievement of our plans, including local authorities, flood risk management authorities and our regulators.

7.2.3 Working with our stakeholders as they develop their adaptation plans

A number of our stakeholders, particularly local authorities, face similar challenges to us as they too take action to adapt to climate change. We will continue to engage with local authorities in our role as a Statutory Risk Management Authority under the Flood and Water Management Act 2010. We will also support local authorities to produce surface water management plans, if they require it.

7.2.4 Ensuring economic and environmental regulation to facilitate the right response to climate change

It is important that the approaches we take to adapt to climate change are considered in the context of the regulatory framework in which we operate. Effective adaptation to climate change will require appropriate investment in sustainable and innovative solutions, and financing that can be accessed at reasonable cost. We need to ensure we find the right balance of taking action to adapt without placing an undue cost burden on our customers, or adopt capital or energy intensive approaches that could adversely impact our commitment to carbon reduction. Ofwat will play an important role in ensuring these behaviours are encouraged.

We believe that ongoing engagement with Ofwat is vital to ensure the integration of adaptation into ‘business as usual’. As Ofwat reviews its approach to the next price review, we are making a constructive contribution to its development.

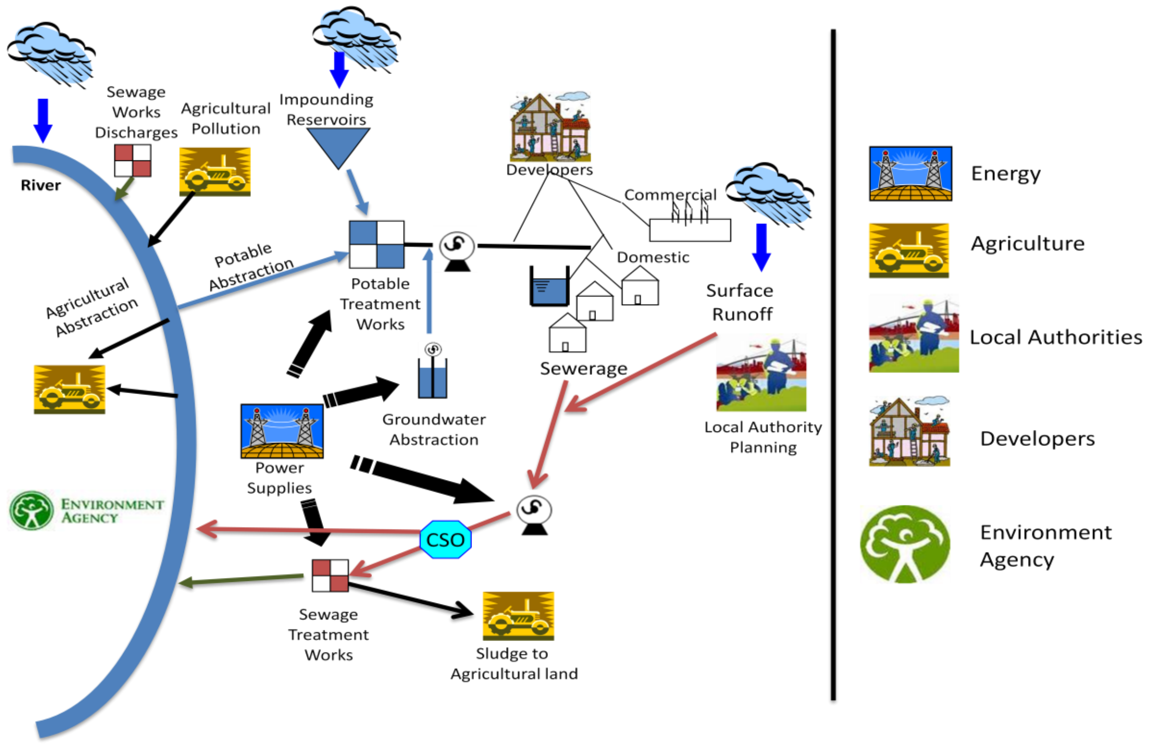
We have also identified significant impacts of climate change that could require a change in approach to environmental regulation both in terms of discharge consenting and abstraction licensing. We will continue to work with the EA as it considers its future approach.

8. Dependencies and interdependencies

Through the risk assessment and stakeholder engagement we have been able to identify a number of key dependencies we have on other parties, such as our critical supplies of power, chemicals and telecoms/ICT. In addition we have identified a number of stakeholders on which we have interdependencies in order to manage our climate change risks (see Figure 8.1 below and Appendix 5).

We will manage these dependencies and interdependencies through on-going stakeholder engagement. We have communications plan to ensure this report is reviewed and discussed further with our key stakeholders. Views of stakeholders were taken into consideration in the development of our AMP 5 business plan, which included schemes related to resilience, sewer flooding and efficiency. In order to ensure that any actions are put in place to manage climate change risks, particularly those which are dependent upon or interdependent with other parties, we will continue to engage with our stakeholders.

Figure 8.1 Key dependencies and interdependencies



8.1. Dependencies

8.1.1 Ofwat

Our economic regulator, Ofwat, is one of our key dependencies in adapting to climate change. Through ongoing engagement with Ofwat we aim to ensure that climate change is fully integrated into the PR14 process. We have taken into account Ofwat's Good Practice from the 2009 Price Review (Ofwat 2010) document and as such will continue to ensure that we have a sound evidence base when putting together our future business plans. We will ensure that our process for the identification and appraisal of investment options is well researched and minimises the level of uncertainty in our climate change risk assessments and options identification and appraisal. We are also working with Ofwat to ensure that the PR14 process fully embeds climate change into its consultation and methodology at the earliest possibility.

8.1.2 The Environment Agency

The EA set limits on abstraction and on discharge. If the EA make changes to abstraction licences either in the form of sustainable reduction or non-renewal of time limited licences under the Habitats or Water Framework Directives, this will impact on our Water Resource Management Plan. Such changes may increase our dependency on other sources.

We would expect discharge consents to become tighter as river flows decrease with increasing summer temperature and decreased precipitation. To treat waste water to higher standards requires more energy and carbon intensive processes. As a result we are dependent upon the Environment Agency to set limits which do not contradict the principles of sustainable adaptation, or are not at odds with our efforts to reduce our carbon emissions. We are working with the Environment Agency to develop a flexible approach to discharge consents to minimise this effect.

The EA also have a responsibility for flood defences there is, therefore, a dependency on understanding the potential impacts of any defence strategy and the resultant impact downstream. Decisions over what to defend and where or to use managed realignment could affect our own decisions. We are also working closely with the EA to understand how our flood defence strategies, such as those at the Mythe water treatment works, could have an effect on river flows. We are working closely with the EA to minimise the overall cost of flood defence projects where they affect our assets or operations.

8.1.3 Energy suppliers

In some 2009/10 some 20% of our power requirement was met from self supplied renewable energy. We are, however, still dependent upon electricity imported from the grid to run our operations. Through discussion with our energy suppliers, GDF and EDF, we understand that the highest risks are in relation to failure of the energy infrastructure, rather than in the production. Energy producers are responding to the Reporting Power as a sector, rather than as individual companies, while National Grid were one of the first Reporting Authorities to respond to the Adaptation Reporting Power. From our discussion with EDF and GDF we understand that there are potential risks to the failure of power plants, but that this would not affect their ability to continue to supply electricity to our sites. Failure of electricity substations at high temperatures or damage to pylons from storms are higher risks. We need to understand this risk in more detail and to understand what National Grid and Central Networks are doing in order to mitigate that risk. We will continue to grow our renewable energy portfolio.

8.1.4 Information technology and telecommunications

We are highly dependent are upon ICT and telecommunications networks, to allow customers to contact us, respond quickly to customers needs and for the operation of a number of our systems. As noted in Chapter 3 our primary ICT data centre is supplied by two energy companies from two different sources. A high level of resilience is also already built into our telecoms network to mitigate risks of single points of failure. Customer Operations Service Centre, which deals with customer issues such as leakage, loss of supply, pressure and discolouration can power over to a second supply. In addition use of mobile network, worked closely with the supplier to ensure resilience and keep cellular traffic going. Furthermore we do have alternative systems such as use of the same network as the Emergency Services, use of satellite technology to ensure flexibility and reduce the numbers of single points of failure.

8.1.5 Suppliers

Site access is important for our suppliers, particularly in relation to chemicals and fuels (vehicle and plant). Certain volumes are kept in reserve as a contingency against failure of the supply chain. In addition, the Procurement and Supply Chain department build contingency plans into contracts to ensure continuity of supply.

8.2 Interdependencies

8.2.1 Local authorities

Local Authorities have been given a statutory responsibility for surface water management and sustainable drainage systems under the Floods and Water Management Act 2010. There is, therefore, an opportunity to work with local authorities to separate surface water and foul water, thereby reducing the risk of combined sewer overflows and sewer flooding. In addition we are working with local authorities on a range of planning issues to reduce surface water flow, increase efficiency and implement grey water recycling through better development and re-development. This will help us reduce the risk of local authority constituents suffering from sewer flooding, and reduce demand for clean water. We are working with local authorities around our region through the regional climate change partnerships and the development of their Surface Water Management Plans to develop collaborative options to adapting to climate change. The success of our strategy is dependant on local authorities following through on their responsibilities under the Act.

8.2.2 Land managers

Land managers and owners such as The Forestry Commission, The Crown Estate, The Peak District National Park, The National Forest and farmers have the ability to affect surface water run-off within the catchment. This will have an impact on both water quality, through diffuse or point source pollution and the ability of the catchment to retain water. By working collaboratively with these groups we can retain water within the catchment and reduce levels of diffuse pollution. There may also be conflicts in abstraction from both groundwater or rivers, on which Severn Trent and these groups are reliant. This will increase pressure on raw water availability in dry conditions as well as putting pressure on ecosystems. It is, therefore, important that as resources become more scarce that we work together to use these resources sustainably. We will work with the NFU and their members as well as other land users and the EA in order to develop sustainable catchment management solutions and Catchment Abstraction Management Strategies.

9. Barriers to implementing our adaptation programme

We recognise that we need to assess the risks posed by climate change and take sustainable actions to mitigate those risks. The water industry does not, however operate in a vacuum. There are technical, regulatory, financial, political and social barriers to implementing an adaptation programme. This section identifies what we perceive to be the key barriers, what can be done to remove those barriers and who should be responsible.

9.1 Lack of clear integration of UK National Adaptation Plan with other Government policies

This report highlights that there are a number of cross-sector dependencies and interdependencies that need to be managed if we are to adapt effectively. As such we believe that there is benefit in Government setting out a national, cross-sector vision for climate change adaptation in the context of government policies, such as The Water White Paper and the Water Resource Management Planning review.

We need to understand the implications of others adaptation plans and their effects on our operations. Government should communicate its vision to all sectors, promote good practice adaptation, clarify the long term strategy for economic regulation and facilitate dialogue between regulators.

We are currently working with stakeholders and will continue this work to ensure that our climate change risks are fully understood. We will, therefore factor the findings of this report into our response to the Water White Paper and other relevant consultations.

While progress has been made in the production of the Treasury's National Infrastructure Plan 2010, communication of the outcomes and implications of other Governmental plans at the earliest opportunity would be beneficial.

9.2 Environmental regulation

Climate change for the water industry will primarily affect our ability to comply with current legislation controlling our waste water discharge and limits to water abstraction from both rivers and groundwater.

9.2.1 Discharge consents

Climate change projections show a trend towards warmer, drier summers. This will reduce river flows increasing biological sensitivity to the discharges from our sewage treatment works. Furthermore reduced flows will also place greater onus on diffuse pollution from within the catchment.

As a result this is likely to make meeting the already extremely challenging and energy intensive objectives of the Water Framework Directive even more costly.

We are working closely with the EA to develop a programme of variable discharge consents, where concentration of discharge varies with river level and therefore takes account of dilution. Our project 'Balancing Carbon and Ecology' (see Section 5.1.2) is a good example of this. We will also continue to work closely with our stakeholders to develop catchment-wide solutions to minimise diffuse pollution.

9.2.2 Abstraction licensing

As river levels decrease, European Directives may also drive a tightening of abstraction licences or the licence being revoked. This is likely to result in a significant increase in capital investment to provide alternative sources of water and is likely to drive significant review of, and changes to the way we operate.
We feel that environmental regulators responsible for the delivery of these Directives consider more flexible approaches to licensing to enable effective and sustainable adaption.

We believe a model for water trading could also help ease the pressure on abstractions by optimising the use of water resources on a national scale. We will continue to build greater strategic capacity within our own network. We will also use this as an opportunity to ensure more connectivity across company boundaries to enable trading.

We will also continue to work with our customers to promote water efficiency, increase metering and reduce leakage within our system to help reduce demand. We will also work to develop relationships with local authorities, planners and developers in our region to promote the building of houses which meet Level 3 of the Code for Sustainable Homes, thereby driving inbuilt water efficiency.

9.3 Economic barriers

Our ability to adapt depends partly access to finance, through the Price Review Process but also through funding available to government agencies and local authorities.

9.3.1 Economic regulation

At present the water industry is funded in five year time periods. Effective adaptation to climate change requires investment in flexible, innovative, low-carbon and sustainable solutions. This requires access to finance as it is needed.

We need an approach which will not place undue burden on customer bills or result in the adoption of capital and energy intensive solutions which adversely affect our commitment to carbon reduction.

In April 2010, Ofwat published a report on Climate Change Good Practice from the 2009 Price Review, the aim of which was to promote improvement and highlight elements of best practice among the companies in planning for climate change. Examples of best practice were highlighted where the business case was well evidenced and researched, where detailed risk assessments had been carried out and where the benefits to customers were clearly demonstrated. Ofwat have committed to:

- Enhancing the evidence base by publishing relevant information from the last price review
- Encouraging a consistent approach to climate change through collaboration with stakeholders

- Working with the sector, Defra, UKCIP and the Adaptation Sub-Committee to ensure that the statutory adaptation reports contribute towards effective adaptation
- Carrying out their own study of adaptation which aims to provide guidance for when they next set price limits
- Reveal the embedded and operational carbon emissions from the companies' activities. They will provide evidence to the emerging debate on local environmental quality and carbon emissions
- Review the long-term aspects of the price setting framework, including the approach for when they next set price limits. This includes a consideration of how cost-benefit analysis is used and the balance between long-term risks and incentives.

It is our responsibility to develop the most robust business case, using the best available evidence to increase the likelihood of securing finance for long term projects related to climate change. We will:

- Use this risk assessment to inform our AMP6 investment strategy.
- Test the sensitivity of our water resources and supply network to the range of climate variables using the UKCP09 climate change scenarios.
- Screen the adaptation options that get promoted in our 2014 Final Business Plan using the process we developed with UKCIP.
- Work closely with Ofwat to understand how to manage uncertainty and to develop long term innovative solutions, rather than short term capital intensive solutions, taking account of any best practice available.

9.3.2 Customer Willingness to Pay

Customers may be unwilling to pay more for their water services because of a belief that water is not a scarce resource and due to a lack of understanding, and in some cases acceptance, of climate change.

In the Price Review 2009 process, companies were required to demonstrate consumer support for the improvement through 'willingness to pay' surveys. Our Willingness to Pay (WTP) surveys showed that there was a high willingness to pay to reduce interruptions to supply, reduce leakage, increase supply capacity and decrease in internal sewer flooding. Customers were less willing to pay to address low river flows, external sewer flooding and controlling river pollution.

Ofwat's acceptance of our business cases for investment in climate change adaptation will be based, not only on the best available evidence of climate change, but also on customer willingness to pay for maintenance or improvement of service.

Future WTP research will need to separate out potential long-term interruptions from short-term. How the questions will be put to customers is part of an UKWIR project starting in 2011, after this report has been submitted. In the meantime we will continue to engage with our customers.

9.3.3 Funding for government bodies

We perceive an additional barrier to be cuts in Government funding for local authorities, flood defences or flood forecasting/early warning.

Reductions in local authority funding may render them unable to deliver on their responsibilities under the Flood and Water Management Act (see Section 3.2), which will put additional pressure upon our sewers and treatment works. We are starting to work with them to encourage them to use their new powers to progressively reduce the amount of surface water entering the sewerage system. We welcome the Government's commitment in its National Infrastructure Plan 2010 to promoting sustainable surface water drainage systems and to support local authorities in taking forward local flood risk strategies and to fully fund their new roles. Further to this we are assuming that both local authorities and Government follow through on their commitment to the Flood and Water Management Act. Failure, either due to political commitment or lack of resource, to deliver on duties under the Act will act as a further barrier to adaptation.

Reductions in funding available to the EA may lead to changes to flood defence strategies which currently protect some of our assets. Reductions in funding for flood defences could increase our susceptibility to flooding and would necessitate the construction of our own defences. Capital costs for which would be passed on to customers or need to be built into future business plans.

To overcome these potential issues we will:

- Work with local authorities to share information, experience and knowledge, on sewer exceedence and surface water flow
- Work with the EA to share information on river and flood modelling
- Build resilience within our own network and to ensure customers are not reliant upon a single source of water supply

9.4 Evidence and uncertainty in the climate projections

As discussed in Jones *et al*., (2009) there is still a degree of uncertainty in the climate change scenarios, due to natural variability, modelling inaccuracies and unpredictable future anthropogenic emissions. There is also a high degree of uncertainty over future extreme events such as convectional precipitation, snow, storms and gales.

In undertaking this report we have taken into account the full range of probabilities in assessing climate change risk. We are aware that there have been improvements made to the UKCP09 Weather Generator, that may help us understand such changes. Due to the timescales involved we have, however, been unable to incorporate those results into this report.

We will:

- Continue to engage with climate change scientists to understand better the nature and impact of any change to uncertainty in the models.
- Work with UKCIP and the data to fully understand the implications and the limitations of the projections.
- Review changes to the projections in our annual updates of our Water Resource Management Plan and in the development of our AMP 6 Business Plan.

In previous years new versions of the projections have been received too late for inclusion in our WRMP and our five year business plan. It would be beneficial if Defra could take this into account if and when new projections are planned.

At the time of writing, UKCIP had funding from Defra until 2011. If changes are to be made either to the nature of the climate projections, the delivery agent, or if there are to be no new climate change projections this will greatly affect our ability to carry out detailed risk assessments in future years.

Any changes to, or new versions of the UKCP09 need to be available prior to summer 2012 if they are to be fully integrated into our PR14 submission. If new projections are not available we will have to use UKCP09 and acknowledge the level of uncertainty. It is likely that this will make it more difficult to put together a sound business case to secure funding for adaptation options.

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Appendices

Appendix 1 - Methodology

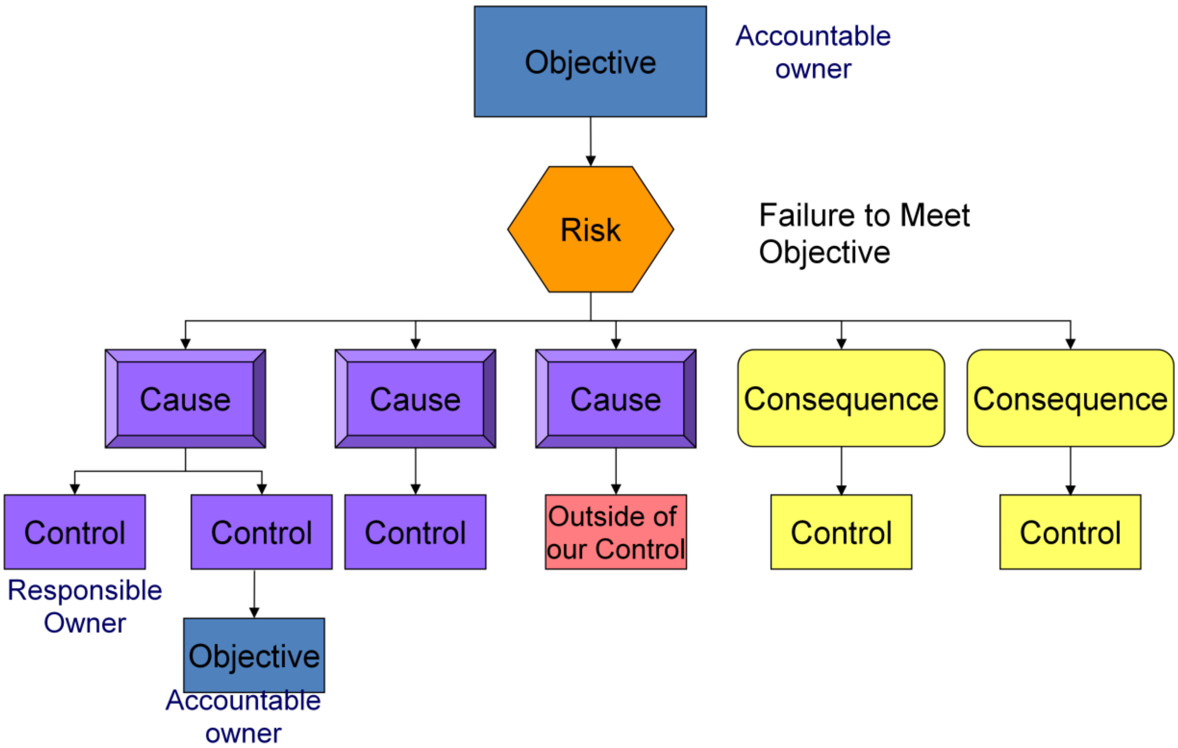
A1.1 Current approach to risk

Climate change is assessed within our Enterprise Risk Management (ERM) system, our Water Resource Management Plan (WRMP) and within our 2009 Business Plan, submitted to Ofwat as part of the Price Review process. The WRMP and the Business Plan both used the UKCIP02 climate change projections.

Our ERM process (Figure A1.1) is built around our key objectives, and risk is considered as the potential failure to achieve an objective. In order to manage those risks which may lead to failure, we consider both potential causes of failure and also the potential consequences of failure to achieve each significant organisational objective, which are typically considered over a five year planning period. The process requires an assessment of controls in place to mitigate each identified cause or consequence and for improvement actions to be put in place where needed to improve controls and thus reduce the risk exposure. Risks are reported to our Executive team and to the Audit Committee every six months who challenge aspects of the process and the risk information provided. The process has been designed to require a degree of subjectivity in assessing impact and likelihood of risks in order to provoke debate and to allow effective prioritisation of risks and responses.

The ERM process is administered by a small central team who provide support to key parties through a network of "risk coordinators". These are individuals who sit within the individual business teams and therefore understand both the risk management process and the team objectives and processes.

Figure A1.1 Enterprise Risk Management system overview



Using this methodology, climate change was assessed as a cause of failure for a number of our key objectives. The Table A1.1, below, highlights some examples of the climate change impacts and associated controls in place which were recorded within the ERM process as at November 2009 prior to carrying out the additional more detailed climate change risk assessments described in this report. As described within this report, the results of these assessments will be fed back to the ERM risk coordinators as part of the regular review and challenge of risk information by the central Risk & Compliance team to help ensure that all relevant climate change impacts are appropriately considered within the ERM process.

Table A1.1 Current Climate Change risks identified by ERM process.

Risk Description **We may fail to...**	**Cause Description**	**Control(s) description**
... effectively install meters in a timely and cost effective manner	Extreme weather e.g floods	Forecasting Plans (Meter exchange/Fropt)
... ensure that key materials, goods or services that support the fundamental operation of the organisation are available as required	Natural disaster affects the supply chain	Business Continuity Assessment on critical suppliers
		Dual source critical commodity areas
		Regular monitoring of key raw material pricing
... provide suitably resilient water treatment works	Poor raw water	Monitoring raw water response
		Drinking Water Safety Plans
		Smell Bells
		Oil and water monitors
		Chemisafe
		Catchment management Process
		Source Management (Quality)
		Quality blending
		Pollution monitoring (POLWARN)
	Severe weather	Severe weather plans
	Insufficient water to treat	Resource management (quantity)
		Sufficient raw water storage
		Enhanced strategic grid

... monitor, inspect, report, and maintain dams	Natural events (eg. earthquakes, landslides, rainfall)	Overflows from dams set at maximum conceivable flood level
		Tree planting programme
		Hillside (landslide) monitoring programme
		Retained expert panel
... receive, treat and dispose of sewage	Weather	Review of rainfall data and long-term planning

A1.2 Detailed climate change risk assessment

We take climate change into account within our corporate risk management system at a strategic level and have used UKCIP02 to put together our final business plan. The UKCP09 data were published too late in the PR09 and WRMP processes to take into account. As a result and to meet the requirements of the Direction under Adaptation Reporting Power we have carried out a more detailed climate change risk assessment.

A1.2.1 Evidence and expertise

The latest set of UK climate change predictions (UKCP09), released in June 2009, were used to assess the risks posed by climate change to our operations. UKCP09 gives probabilistic projections for a range of climatic variables over several future time periods, for three emissions scenarios.

The spatial resolution of UKCP09 projections over land areas is 25km, however these gird squares may not be combined to infer regional changes (Murphy *et al*., 2009). There are, therefore, probabilities of change for administrative regions and river basin regions (see Figure A1.2). Administrative regions encompass the countries of Wales, Northern Ireland and Scotland (the latter subdivided into three climate regions), and the nine administrative regions of England. While the river basin regions are based on those within the Water Framework Directive they were not used in the assessment. For the purposes of the climate change risk assessment, data for Wales, the East Midlands and West Midlands administrative regions were used as these regions align best with our area of operation (see Figure 1.1 Chapter 1).

The UKCP09 data provide a range of temporally averaged scales over which climate change can be assessed. The projections are averaged over each of seven future overlapping 30 year time periods, stepped forward by a decade, starting with 2010–2039 (see Figure A1.3). These future time periods are referred to by their middle decade, starting from the 2020s (2010–2039) and ending with the 2080s (2070–2099). All changes are expressed relative to a modelled 30-yr baseline period of 1961–1990 (Murphy, 2009). Data for the 2020s, 2050s and 2080s were selected for the purpose of this risk assessment. Focus was, however, on the 2050s and the

2080s, as the next two to three decades are relatively insensitive to changes in the climate system and the projections only begin to diverge after the 2040s.

The UKCP09 projections tool provides data for three emissions scenarios[16]. These scenarios take into account the full basket of greenhouse gases[17], but are non-interventionist and therefore do not account for any political actions to mitigate against climate change. All three emissions scenarios were used to ensure a range of predicted outcomes was considered. This approach helps us to consider adaptation to the widest possible range of outcomes over the long term.

Figure A1.2 UKCP09 Administrative Regions & River Basin Regions (Jenkins *et al*., 2009)

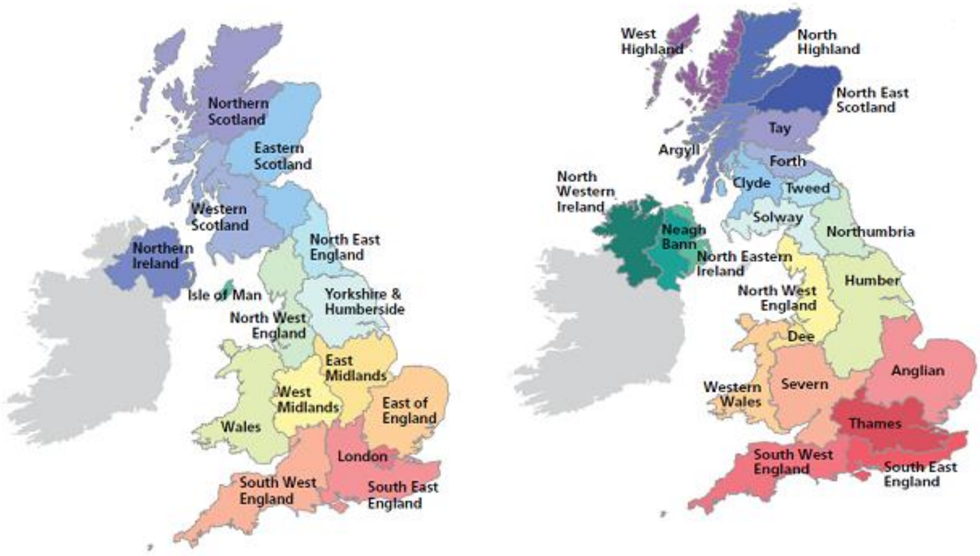
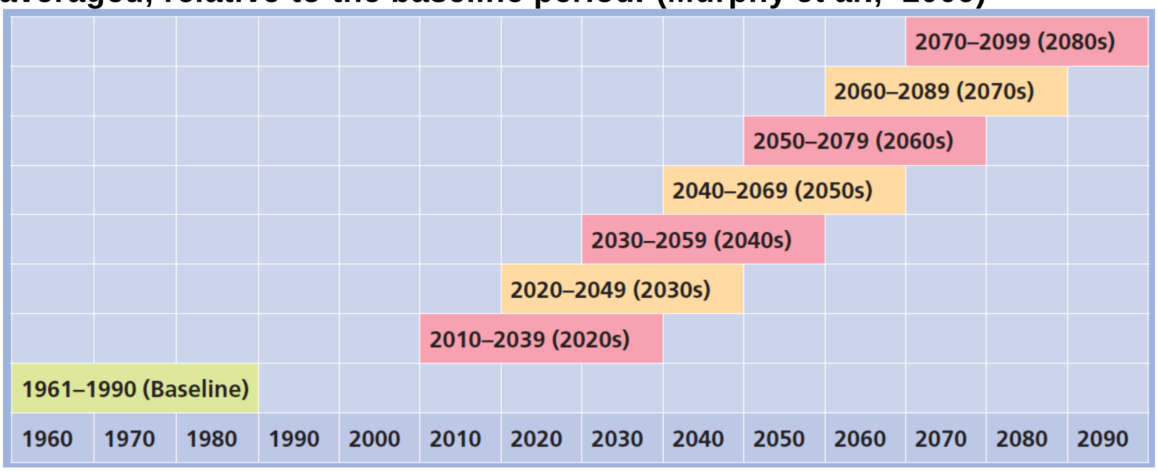


Figure A1.3 The seven 30-yr future time periods over which projections are averaged, relative to the baseline period. (Murphy *et al*., 2009)



[16] IPCC Special Report on Emissions Scenarios: A1FI (high emissions), A1B (medium emissions) and B1 (low emissions) (Jenkins et al., 2009)

[17] Carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs)

There is a large degree of uncertainty in the projections due to: natural variability of the climate, modelling uncertainty and uncertainty over future anthropogenic greenhouse gas emissions. The projections are however probabilistic and assign a probability to different possible climate change outcomes. The central estimate represents the median position, or a 50% probability, with the 10% probability representing the scenario of very unlikely to be less than and the 90% probability being very unlikely to be more than. In each case the possible range of probabilities was taken into account in assessing the impact of the projection on our operations.

To supplement the UKCP09 projections the UKCP09 Weather Generator and Threshold Detector were used to quantify changes in weather variables such as temperature and precipitation on a daily basis, on 5Km grid squares. The weather generator was run for all three time periods (2020s, 2050s and 2080s), for the medium emissions scenario, using monthly temporal averages and the 50 percentile for temperature and precipitation for support services and the 50% for temperature in the waste water analysis and the 10 and 90 percentiles for precipitation.

On behalf of the water sector UK Water Industry Research Ltd. (UKWIR) commissioned a study to provide guidance on incorporating climate change impacts, particularly UKCP09 and the Weather Generator, into the modelling of sewerage networks (Arkell *et al.*, 2010). The outputs of this report aided in defining some thresholds for sewer flooding and have, therefore, also been used to inform the climate change risk assessment on waste water services.

A1.2.2 Climate change risk assessment

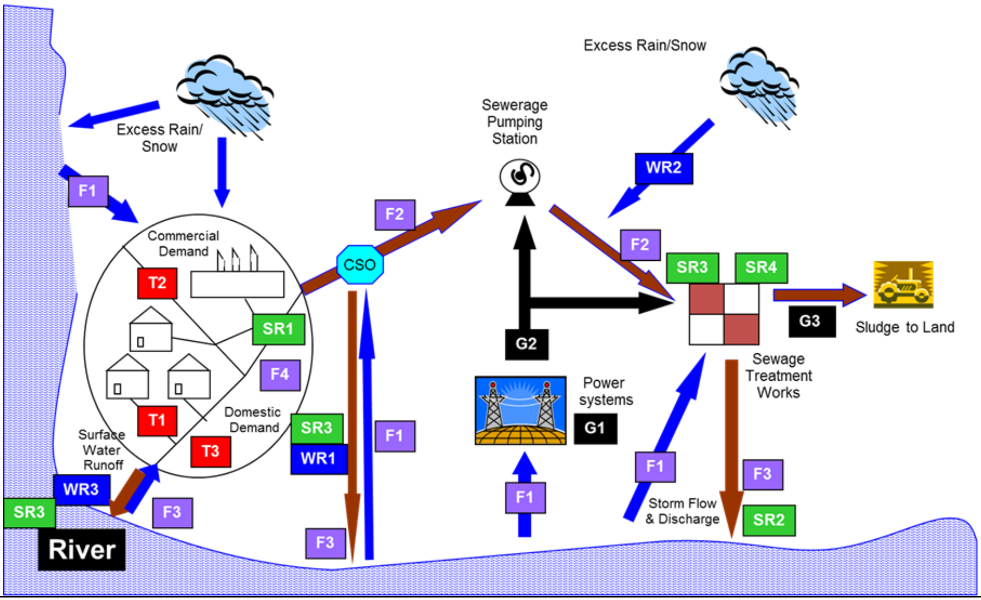
To complete the risk assessment process we formulated and adopted a staged approach, which involved engagement with a wide range of members of Severn Trent Water’s and incorporated both expert opinion and the findings of technical reports assessing the impacts of climate change on our activities. The stages we followed are outlined below.

Stage 1: Identification of the key activities.
Stage 2: Identification of key climate drivers – use of UKCP09 to identify the range of possible values for these climatic factors under three possible emissions scenarios (low, medium and high).
Stage 3: Use of our historic data to determine the severity of impacts that we may face under the range of possible values identified in stage 2.
Stage 4: Consultation with experts
Stage 5: Full Climate Change Risk assessment on key activities and variables.

A1.2.3 Identifying climate change variables

In order to identify how climate change may have an impact upon operations Waste Water Services identified all the activities associated with Waste Water treatment, pumping and discharge from sink to receptor (Figure A1.4). Similarly Water Services developed a process flow documenting all activities associated with water treatment and pumping from sources to tap (Figure A1.5). Both of these process flows also highlighted areas of support services which may be at risk from changes in the climate such as supply chain, power supply and staff health and safety (Table A1.2)

Figure A1.4 Identification of Waste Water Services activities affected by climate change

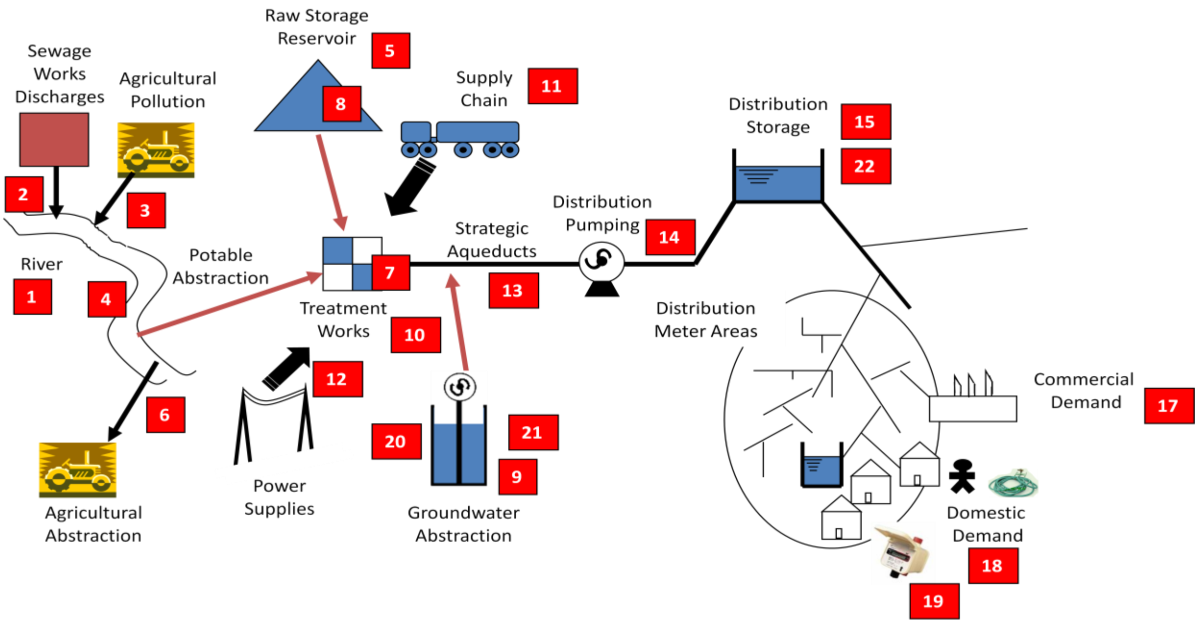


Legend	
Abbreviation	**Climate Change Variable**
T	Change in Temperature.
F	Sewer and River Flooding
WR	Heavy Winter precipitation/ Intense Summer storms
SR	Low Summer Precipitation
G	Impacts due to climatic/other variables.

Ref	Risk Description
SR1	Longer dry periods leading to more sewer blockages
SR2	Low river levels reducing river water quality and tighter consents
SR3	Reduced quality urban runoff
SR4	Dry weather leading to low sludge levels – Affecting CHPs.
F1	River Flooding – service failure due to asset loss.
F2	Capacity of sewerage system to cope with peak demands
F3	Higher River flood levels affects sewer / STW outfalls
F4	Sewer Flooding – Excess rain & flooding
WR1	Increased discharge – CSO
WR2	Rise in sudden storms/rain – High sludge flow to STW
WR3	Excess precipitation leading to excess surface water discharge.
T1	Ground movements due to soil moisture deficit, increased failure of small sewers.
T2	Changes in commercial consumption patterns and activity. Global manufacturing trends
T3	Changes in domestic demand patterns, peak Summer demands / population relocation.
G1	Rise in power interruptions due to temp rise / increased flooding

G2	Rise in power costs/triads due to increased demand in summer.
G3	Supply chain pressures during severe weather / flooding / transport difficulties

Figure A1.5 Identification of Water Services Activities affected by climate change



Ref	Impact Description
1	Low Summer river flows, abstraction restrictions
2	Poor river quality through reduced dilution for sewage effluent
3	Agricultural run off – changes to farming practice & storm run off
4	Flooding risks intense storms
5	Algal blooms, eutrophic water – temperature & nutrients
6	Abstraction licence challenges
7	Treatment process challenges high temperatures / bioactivity
8	Raw Reservoir low levels – drought
9	Groundwater aquifer depletion / recharge
10	Maximum Treatment Works capacity
11	Supply chain pressures during severe weather / flooding / transport difficulties
12	Increased power interruptions
13	Ground movements due to soil moisture deficit, risk of aqueduct failures
14	Capacity of distribution system to cope with peak demands
15	Adequacy of distribution storage reservoirs
16	Ground movements due to soil moisture deficit: increased leakage breakout in summer, less freeze/ thaw in warmer winters
17	Changes in commercial consumption patterns and activity. Global manufacturing trends

18	Changes in domestic demand patterns, peak Summer demands, non essential use
19	Usage tariffs
20	Saline intrusion into groundwater / river abstraction
21	Ground fissures from soil moisture deficit pollution pathways for groundwater
22	Increased temperature, bacteriological activity in distribution system

Table A1.2 Support Services activities affected by climate change

Support service area	**Definition**
Staff health and safety	Staff well-being whilst at work
Logistics	Access to Severn Trent Water sites for staff and suppliers
Supply chain	Requirements from external parties (e.g. Diesel, Chemicals, postal delivery services)
Power supply	Power and heating requirements for all sites
Staff travel	Commute to and from work, Business related travel (between sites, and off site working)
Telecommunications	Internal and external communications, telemetry, metering/billing
Information Technology	Internal and external communications, metering/billing
Finance/Insurance	Cost of Insurance

The activities identified in these process flows were then mapped against the range of climate change variables identified from UKCP09. These variables were then screened, using experience and judgement from our own and external experts, to produce a sub-set of key climate change variables to be analysed further. The screening involved a simple scoring systems as shown in Table A1.3, A1.4 and A1.5) below. This initial screening highlighted those activities likely to be most significantly influenced by future changes in our climate.

Based on or “drain to river” assessment we have identified the following key climate change variables as important to waste water services:

- Low Summer Precipitation.
- High Winter precipitation
- Intense Summer Storms
- High Summer Temperatures.

Based on our water services source to tap assessment, the weather variables we have assessed as being most material to water services our risk assessment are:

- Summer mean temperature
- Summer mean daily maximum temperature
- Summer warmest day
- Summer mean precipitation
- Summer mean daily maximum precipitation

- Winter mean temperature
- Winter mean daily minimum temperature
- Winter mean precipitation
- Winter mean daily maximum precipitation
- Annual mean precipitation

The variables which were identified as important in maintaining support services were:

- Summer Mean Temperature
- Temperature of warmest Summer day
- Winter Mean Temperature
- Summer Mean Precipitation
- Winter Mean precipitation
- Cloud cover (Sunshine hours)
- Storminess
- Snow

Table A1.3 Results of the initial assessment of water supply activities their vulnerability to changes in climate variables

Ref	Impact Description	Annual precipitation	Warmest Summer day	Winter mean temperature	Winter mean daily minimum temp	Summer mean temperature	Summer mean daily max temp	Winter mean precipitation	Winter mean daily max precipitation	Summer mean precipitation	Summer mean daily max precipitation
1	Low Summer river flows, abstraction restrictions	√	√			√	√	√		√	√
2	Poor river quality through reduced dilution for sewage effluent	√				√		√		√	
3	Agricultural run off – changes to farming practice & storm run off	√	√			√	√			√	√
4	Flooding risks intense storms								√		√
5	Algal blooms, eutrophic water – temperature & nutrients		√	√	√	√	√				
6	Abstraction licence challenges	√		√		√	√	√		√	
7	Treatment process challenges high temperatures / bioactivity		√	√		√	√				
8	Raw Reservoir low levels – drought	√		√		√	√	√		√	√
9	Groundwater aquifer depletion / recharge	√		√		√		√		√	
10	Maximum Treatment Works capacity		√			√	√				
11	Supply chain pressures during severe weather / flooding / transport difficulties		√		√		√		√		√
12	Increased power interruptions		√		√	√	√				
13	Ground movements due to soil moisture deficit, risk of aqueduct failures	√		√		√		√	√	√	√
14	Capacity of distribution system to cope with peak demands		√			√	√			√	
15	Adequacy of distribution storage reservoirs		√			√	√			√	
16	Ground movements due to soil moisture deficit, increased leakage breakout in Summer, warmer winters – less freeze thaw			√	√	√		√	√	√	√
17	Changes in commercial consumption patterns and activity. Global manufacturing trends	√		√		√				√	
18	Changes in domestic demand patterns, peak Summer demands, non essential use		√			√	√			√	
19	Usage tariffs					√	√				
20	Saline intrusion into groundwater / river abstraction	√		√		√		√		√	
21	Ground fissures from soil moisture deficit pollution pathways for groundwater			√		√				√	
22	Increased temperature, bacteriological activity in distribution system		√	√	√	√	√				

Table A1.4 Results of the initial assessment of waste water supply activities their vulnerability to changes in climate variables

Ref	Risk Description	High Temperature (T)	Low Summer Rain (SR)	Intense Summer storm (WR)	Heavy Winter Rain (WR)
SR1	Longer dry periods leading to more sewer blockages	√	√		
SR2	Low river levels reducing river water quality and tighter consents		√		
SR3	Reduced quality urban runoff		√		
SR4	Dry weather leading to low sludge levels – Affecting CHPs.	√	√		
F1	River Flooding – service failure due to asset loss.			√	√
F2	Capacity of sewerage system to cope with peak demands			√	√
F3	Higher River flood levels affects sewer / STW outfalls			√	√
F4	Sewer Flooding – Excess rain & flooding			√	√
WR1	Increased discharge – CSO			√	√
WR2	Rise in sudden storms/rain – High sludge flow to STW			√	√
WR3	Excess precipitation leading to excess surface water discharge.			√	√
T1	Ground movements due to soil moisture deficit, increased failure of small sewers.	√	√		
T2	Changes in commercial consumption patterns and activity. Global manufacturing trends	√			
T3	Changes in domestic demand patterns, peak Summer demands / population relocation.	√			
G1	Rise in power interruptions due to temp rise / increased flooding	√		√	√
G2	Rise in power costs/triads due to increased demand in summer.	√			
G3	Supply chain pressures during severe weather / flooding / transport difficulties	√		√	√

Table A 1.5 Results of the initial assessment of support services activities their vulnerability to changes in climate variables

	Climate Variable							
Risk Area	Summer Mean Temp	Summer Mean Daily Max Temp	Winter Mean Temp	Summer Mean Precipitation	Winter Mean Precipitation	Cloud Cover	Storms	Snow
Staff H&S	√	√	√	√	√	√	√	√
Logistics		√	√	√	√		√	√
Supply Chain	√	√	√	√	√	√	√	√
Power Supply		√		√	√		√	√
Staff Travel			√	√	√		√	√
Telecoms	√	√		√	√		√	
ICT	√	√		√	√		√	
Finance/ Insurance			√	√	√		√	

A1.2.3.1 Identifying possible scale of climate change

For each of the identified significant climate change variables the probable range of change was identified for each of the emissions scenarios for each of the 30 year time periods in Wales and the East and West Midlands. In each instance the analysis took into account the best central estimate as well as the probable range at the 10% and 90% probability ranges.

A1.2.3.2 Identifying critical thresholds

In order to help determine critical thresholds above which climate and weather events pose a threat to operations, a number of methods were used. For analysis of the impact of changes in climate and weather the on Support Services the UKCP09 Weather Generator and Threshold Detector were used to determine the possible impact of temperature changes where the default values for heating degree days[18] and cooling degree days[19] and heat waves[20] were used. Water Services used data on past events such as river flows, droughts or dry events to determine the possible impact of future climate on water resource availability. Waste Water also used the Weather Generator to gain a better understanding of high intensity precipitation events, which can then be used to infer the possible impact in relation to sewer flooding. The effect of climate change on the sewerage system will be incremental and no specific critical thresholds have been identified.

[18] Heating days are defined as the number of days when the mean daily temperature in below 15.5 °c and therefore some form of heating would be required.
[19] Cooling days are defined as the number of days when mean daily temperatures is above 22 °c and as a result some form of cooling would be required.
[20] Heat waves are defined as conditions where the maximum daily temperature is greater than 30°c and the minimum daily temperature is above 15°c for a minimum of three consecutive days

A 1.2.4 Initial screening of Water Services risks

Water Services identified a greater number of activities and potential climate change variables than waste water and support services, they therefore undertook a preliminary screening exercise to narrow down the variables further.

Having identified the key climate variables which affect our source to tap activities, we carried out an initial screening to eliminate those activities at low risk of being significantly affected (either positively or negatively) by future climate change. Our screening applied a simple scoring system which weighted the impacts of climate change. This was only applied to the Water Services risks as waste water and support services had fewer to assess. The scoring criteria are shown in Table A1.6 below.

Table A1.6 Initial screening of the significance of the climate driver

Significance of impact of climate driver	Score
High	5
Medium	3
Low	1
No Impact	0

Under these headings a score between 0 and 5 was assessed for each option, with a higher score being awarded where it was deemed likely that the projected change in climate variable would have a greater impact on our activities. Conversely, the lower the score, the smaller the impact the change in climate variable was considered to have in terms of our activities. For example, for groundwater aquifer depletion and recharge, a medium rating (3) was given for summer mean temperature and a high rating (5) was given to winter mean precipitation as the volume of precipitation during the winter months has a significant impact on how well aquifers recharge, particularly following a prolonged period of warm weather which has caused a depletion. Winter daily minimum temperature was deemed to have no impact as this variable does not significantly influence the recharge or depletion of an aquifer.

This initial screening highlighted those activities likely to be most significantly influenced by future changes in our climate. The results of the water services initial screening are shown in Table A1.7.

Table A1.7 Results of initial screening exercise

Ref	Impact Description	Winter mean temperature	Winter mean daily minimum temp	Summer mean temperature	Summer maximum daily temp	Winter mean precipitation	Winter mean daily maximum precipitation	Summer mean precipitation	Summer mean daily maximum precipitation	Score	Person with knowledge of this impact
1	Low Summer river flows, abstraction restrictions	3		3	1	3		5		15	Principal Hydrologist / Senior Water Resources Planner
2	Poor river quality through reduced dilution for sewage effluent			1		3		5		9	
3	Agricultural run off – changes to farming practice & storm run off			3	1			3	1	8	
4	Flooding risks intense storms						5		5	10	Senior Distribution Strategy Analyst
5	Algal blooms, eutrophic water – temperature & nutrients	3	1	3	1					8	
6	Abstraction licence challenges	1		5	3			3		12	Senior Water Resources Planner
7	Treatment process challenges high temperatures / bioactivity			3	5					8	
8	Raw Reservoir low levels – drought	3		3	1	3		5	1	16	Principal Hydrologist
9	Groundwater aquifer depletion / recharge	3		3		5		1		12	Senior Hydrogeologist
10	Maximum Treatment Works capacity	3	3	1	3					10	Principal Hydrologist
11	Supply chain pressures during severe weather / flooding / transport difficulties		3		1		1		3	8	
12	Increased power interruptions		5	1	3					9	
13	Ground movements due to soil moisture deficit, risk of aqueduct					1	1	5	3	10	Leakage Strategy Manager
14	Capacity of distribution system to cope with peak demands	1	1	3	5					10	Senior Distribution Strategy Analyst
15	Adequacy of distribution storage reservoirs			3	5			1		9	
16	Ground movements due to soil moisture deficit, increased leakage breakout in Summer, warmer winters – less freeze thaw	4	5	3	1			3		16	Leakage Strategy Manager
17	Changes in commercial consumption patterns and activity. Global manufacturing trends			3				3		6	
18	Changes in domestic demand patterns, peak Summer demands, non essential use			1	5			3	1	10	Domestic Consumption Monitor Manager
19	Usage tariffs			3	3					6	
20	Saline intrusion into groundwater / river abstraction	1		1		3		3		8	
21	Ground fissures from soil moisture deficit pollution pathways for			3				3		6	
22	Increased temperature, bacteriological activity in distribution system	3	3	3	3					12	Senior Distribution Strategy Analyst

A1.2.5 Full risk assessment.

From the initial screening exercise, the Water Services activities which gained an overall significance score of 10 or higher were taken forward for a more full risk assessment. All waste water and support services risk were carried forwards to full risk assessment.

To ensure we explored the full range of risks and opportunities associated with possible changes in our source to tap activities caused by climate change we engaged with experts in and around the business at one to one consultation sessions. The outcome of the consultation sessions was captured in a detailed Risk Assessment Matrix. The one to one workshops were also used as an opportunity to consider the range of possible mitigation and adaptation options that might be available to reduce the risks and capitalise on any opportunities which may arise due to climate change.

The full risk assessment matrix can be found at Appendix 3 of this CCRA report and the priority risks are discussed in Chapter 3.

Having identified the climate change variables which were significant to our operations, the potential range of change for these variables and, where possible, any critical thresholds above which operations would be under threat from climate change risks a climate change risk assessment was carried out.

The risk assessment initially identified the key climate drivers i.e. change in annual temperature, then indentify the specific climate effect e.g. increased summer temperatures and then identified the possible impact(s) and consequences. Each risk was then assessed on two defined matrices. The first assessment took into account proximity of the risk occurring (Table A1.8) and the likelihood or probability of the risk occurring (Table A1.9). The proximity rating was based on a decadal scale, in line with the UKCP09 projections. The likelihood score was based upon the UKCP09 range of probabilities. The scores for proximity and likelihood were multiplied together to give an overall score out of a possible 25 (See Table A1.10a and b).

Table A1.8 Proximity risk rating.

Proximity	Definition	Value
2020	effects likely to be felt between now and end of 2020s	5
2030	effects likely to be felt within 2030s	4
2040	effects likely to be felt within 2040s	3
2050	effects likely to be felt within 2050s	2
2060+	effects likely to be felt within 2060s and beyond	1

Table A1.9 Likelihood risk rating

Impact	Definition	Scale	Value
Almost Certain	More likely to happen than not	> 50 % chance	5
Likely	Fairly likely to occur	20 – 50 % chance	4
Unlikely	Possible it may occur	10 – 20 % chance	3
Rare	Low, but not impossible	5 – 10 % chance	2
Highly Unlikely	Very low, but not impossible	1 – 5 % chance	1

Table A1.10a Likelihood vs. Proximity score

Risk Factor Score (proximity x likelihood)	**Risk Rating**
20 to 25	Very High
15 to 19	High
6 to 14	Medium
4 to 5	Low
1 to 3	Very low

Table A1.10b

		Likelihood				
		Highly Unlikely				Almost Certain
Proximity	2020	5	10	15	20	25
	2030	4	8	12	16	20
	2040	3	6	9	12	15
	2050	2	4	6	8	10
	2060 +	1	2	3	4	5

The second assessment took into account the size of the population likely to be affected (see Tables A1.11a-c) and the severity of the impact on the environment, society and the business (Table A1.12). Due to the nature of the operations three scales were determined one for water, one for waste water and one for support services. The rationale behind this was that water supply can affect millions of households where as waste water supply focuses on smaller populations. Each category was assigned a score out of five, based on a set of defined criteria (see below). The scores for severity and population were also multiplied together to give a possible score out of 25 (see Table A1.13 a and b).

Table A1.11a Water population size

Population likely to be affected	Definition	Scale	Value
Small	Small number of population affected by reduced supply/loss of supply	More than 10,000 population affected	1
Medium	Moderate size population affected	1,000,000 population affected	3
Large	large population affected by reduced/loss of supply	4,000,000 population affected	5

Table A1.11b Waste Water population

Population likely to be affected	Definition	Scale	Value
Small	Small number of population equivalents affected by reduced supply/loss of supply	fewer than 1,000 population equivalents affected	1
Medium	Moderate size population affected	2,500-5,000 population equivalents affected	3
Large	Large population affected by reduced/loss of supply	More than 10,000 population equivalents affected	5

Table A1.11c Support services population affected

Population likely to be affected	Definition	Scale	Value
Small	Small number of sites, staff or suppliers affected	0-1000 staff or 1-5 sites affected	1
Medium	Moderate number of sites, staff or suppliers affected	1000-3000 staff affected	3
Large	Large number of sites or staff affected or critical suppliers affected	4000+ staff, all sites affected.	5

Table A1.12 Severity of impact

Impact	Definition	Value
Large	Company Wide Impact, high cost of mitigation, large/prolonged environmental impact	5
Medium	Local Impact, medium cost of mitigation, moderate environmental impact	3
Small	Minimal impact on the company and local populations, low environmental impact, low cost of mitigation	1

Table A1.13a Population vs. severity score

Risk Factor Score (proximity x likelihood)	Risk Rating
20 to 25	Very High
15 to 19	High
6 to 14	Medium
4 to 5	Low
1 to 3	Very low

Table A1.13b

		Population/Number of Properties				
		Small (few)				Large
Severity	Large/ Company Wide	5	10	15	20	25
		4	8	12	16	20
	Local Impacts	3	6	9	12	15
		2	4	6	8	10
	Small	1	2	3	4	5

The two score where then combined to give and overall score out of 50. The application of this methodology to our operations can be seen in Chapter 3 and the full risk assessment matrices can be found in Appendix 3

Throughout the risk assessment consideration as given to the quality of the data used to draw conclusions. Each impact was given a pedigree score of 0-4, based on the methodology used by HR Wallingford in the UK CCRA.

0 – Non-expert opinion, unsubstantiated workshop discussion, with no supporting evidence
1 – Expert view based on limited information e.g. anecdotal evidence
2 – Estimation of potential impacts using accepted methods and with some agreement across the sector
3 – Reliable analysis and methods, subject to peer review, and accepted within the sector as fit for purpose
4 – Comprehensive evidence using best practice and published in peer reviewed literature, accepted as the ideal approach.

A confidence grade was also assigned to the risk assessment. For each risk a confidence grade of high, Medium, or Low was assigned.

A1.2.6 Uncertainties in the risk assessment.

Uncertainty is inherent in the UKCP09 data due to natural climate variability, the models themselves and uncertainty in future anthropogenic emissions as discussed in Murphy *et al*., 2009. To deal with these uncertainties the projections are probabalistic. As a result the full rnage of probability has been taken into account in using the projections. Specific uncertainties are addressed in Chapter 4.

A1.2.7 Future climate change risk assessment

As discussed above we have a corporate risk process, ERM. From November 2009 climate change was included within this framework. However, this was at quite a high level. The impacts of climate change on the business may not have been fully understood by those involved in the ERM process, or not deemed a significant business issue within the timeframes usually considered in this process. Moving forward, climate change could be better integrated into the corporate ERM process with some training for the risk coordinators on the impacts of climate change as indicated by the UKCP09 projections. This would enable them to utilise this understanding when challenging the assessments made by risk owners within their teams. This challenge would help ensure that all objectives which could have an impact from climate change in the longer term will have suitable controls identified with action plans, if required, to ensure they are effective within the necessary timeframes. Where a particular impact affects multiple risks within the ERM process a new, higher level, risk would be created and an owner assigned to develop and manage the appropriate response. In addition to this use of the ERM process for identifying and managing Climate Change impacts there would also be an ongoing need for additional risk assessments using the UK climate impacts data, as it is updated, to help inform the ERM and Business Planning processes.

A1.3 Developing adaptation options

The risk assessment was designed to generate a set of priority risks, for which actions to manage those risks needed to be identified and appraised. We plan to embed and incorporate options generation and appraisal arising from this climate change work with our standard periodic review cycle of asset management and planning and adopt the principles of sustainable adaptation. In addition we intend to develop innovative and low carbon solutions, aimed to ensure that action do not have a detrimental effect upon our Key Strategic Intention to minimise our carbon footprint.

In responding to the requirements of the Adaptation Reporting Power we worked with UKCIP to develop a robust methodology for identifying and appraising adaptation options.

In the first instance, with facilitation from UKCIP and bringing in experts from around the water and waste water businesses, a range of options or measures were identified, under three key headlines, which would mitigate against the priority risks identified via the risk assessment;

- Strategic and policy measures such as;
    - Contingency plans associated with failures or disruptions;
    - Monitoring and evaluation of policies and plans; and

- Working in partnership (sector and community based).
- Technical or structural measures such as:
    - Investments in assets and asset management;
    - Upgrade water treatment works to deal with quality issues;
    - Upgrade sewage treatment to deal with reduced capacity of rivers;
    - Measures to address sustainability and enhancement of resources (individual assets and the system as a whole);
    - Ensuring sustainability of measures introduced to deal with other issues (e.g. mitigation) in the context of a changing climate;
    - Buildings and related infrastructure investments; and
    - Investments in operations and H&S procedures.
- Non-structural and non-technical measures: such as
    - Raising awareness about climate change and actions being taken to address it (internally and externally);
    - Demand management efforts;
    - Monitoring and data collection to support understanding of risks, thresholds, sensitivities and performance of assets, operations and measures introduced;
    - Skills development to establish and increase capacity of staff; and
    - Introduction of early warning and improved 'forecasting' systems.

Experts were asked to consider no-regrets options such as avoiding building assets in high risk areas such as flood plains or reducing leakage; low regrets options such as building in additional head room; win-win options such as re-establishment of flood plains and flexible options such as progressive development or investment in line with projected climatic changes. In addition they were asked to consider possibilities where we could beneficially work in partnership with other organisations.

Once a range of options had been identified they were appraised using the following framework (see Table A1.14). Options were given a score out of three for each of the nine criteria to give a possible total score of 87.

Table A1.14 Adaptation options appraisal matrix.

Criteria	High (3)	Low (1)
Flexibility	A measure that you can shift around, turn on/off, bring wide ranging benefits to lots of people; offers choice that can be exerted easily; is adaptable, can be implemented flexibility; is scalable,	Opposite of high (locks you in)
Sustainability	Mitigation, social and environmental benefits not costs. Long asset life.	There is a limited time over which benefits will be enjoyed. Detrimental to community and environment.
Equity	No customers disadvantaged	Some customers disadvantaged
Cost	Has low whole life costs, including capital, operating and maintenance costs.	Has high whole life costs, including capital, operating and maintenance costs
Acceptability	Stakeholder focussed – provides solutions acceptable to wide range	Not acceptable to wide range of stakeholders; likely conflict with

	of stakeholders	some stakeholders
Effectiveness	Very likely to reduce risks	Potential to reduce risk is low or unknown
Timing/ urgency	Note this relates to flexibility considerations (how long will it take to get something up and running?). Short time from initiation to completion; can secure a quick win. A planned approach aligned with the investment period.	Long term to complete (won't be operational quickly) Reactive approach with investment in response to current issues,
Robustness	Is able to operate efficiently across a wide range of variables/uncertainties. Not contingent on third parties. Minimal impacts. Not very risky	Can only cope well with a specific set of variables or uncertainties. May only be effective against one or two variables. Highly sensitive to future changes. Could be susceptible to change in political climate/regulation. Contingent on third parties. Risky
Coherence/ alignment	Consistent / aligned with other strategic objectives. Synergistic (e.g. 3 boxes ticked instead of 1)	Negative impact or conflicts with other strategic objectives

As discussed a number of climate change related schemes will be delivered during the course of AMP 5. The process outlined above will be used to aid in the development of schemes to be put forward within the PR14 and the Water Resource Management Plan processes. This is discussed in more detail in Chapter 5

Appendix 2 – Climate change data

The following section explains how we determined the key variables that were the most significant in terms of the potential impact on our activities.

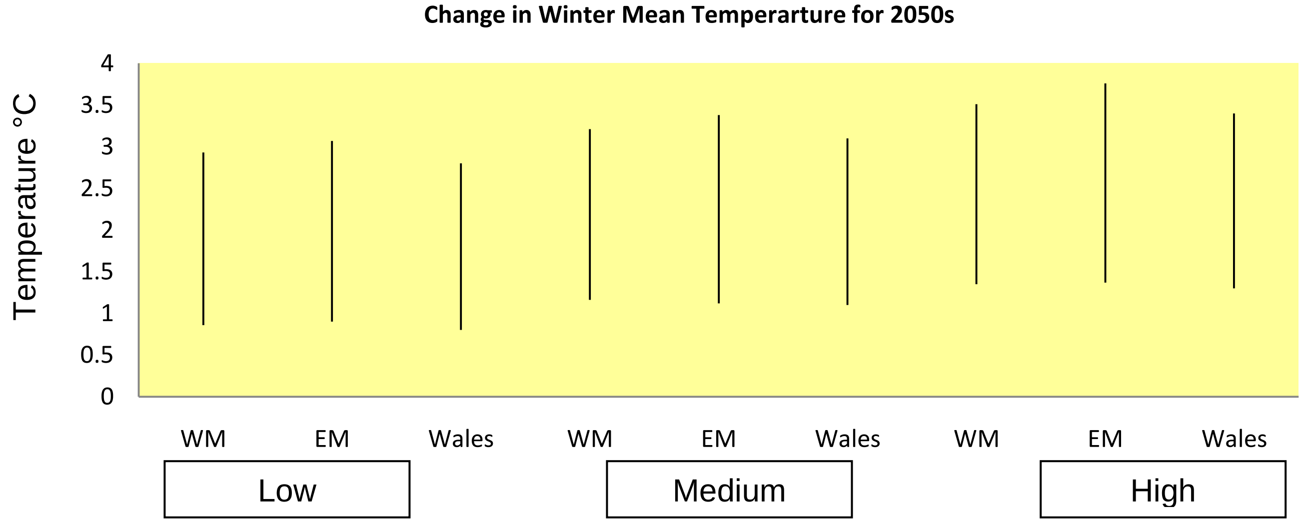
We used the latest set of UK climate change predictions, UKCP09, to determine the range of projections for variables in order to assess the potential risks presented by climate change. UKCP09 gives probabilistic projections for a range of climatic variables over several future time periods, for three emissions scenarios.

For each climate driver we have taken outputs from UKCP09 to help understand the potential impact of predicted climate change on water supply activities. The following section describes the climate change parameters we have extracted from the UKCP09 online tool.

We have considered Wales, the West Midlands and the East Midlands weather variable datasets from UKCP09 to inform our climate change risk assessment, since these areas together closely match the Severn Trent Water's area of operation. For each parameter, we show the projected change under each of the three emissions scenarios up to 2099. The datasets show the projected change in each parameter from the (1961-1990) long term average.

Figure A2.1 Winter mean temperature

2050s		Emissions Scenario								
		Low			Medium			High		
Region		WM	EM	Wales	WM	EM	Wales	WM	EM	Wales
Unlikely to be less than	°C	0.86	0.9	0.8	1.16	1.12	1.1	1.35	1.37	1.3
Best Central Estimate	°C	1.83	1.92	1.8	2.1	2.17	2	2.32	2.47	2.3
Unlikely to be more than	°C	2.93	3.07	2.8	3.21	3.38	3.1	3.51	3.76	3.4



2080s		Emissions Scenario								
		Low			Medium			High		
Region		WM	EM	Wales	WM	EM	Wales	WM	EM	Wales
Unlikely to be less than	°C	1.41	1.4	1.4	1.64	1.6	1.6	2.11	1.98	2
Best Central Estimate	°C	2.47	2.56	2.4	2.86	2.98	2.8	3.44	3.61	3.3
Unlikely to be more than	°C	3.74	3.91	3.6	4.37	4.62	4.2	5.18	5.56	5

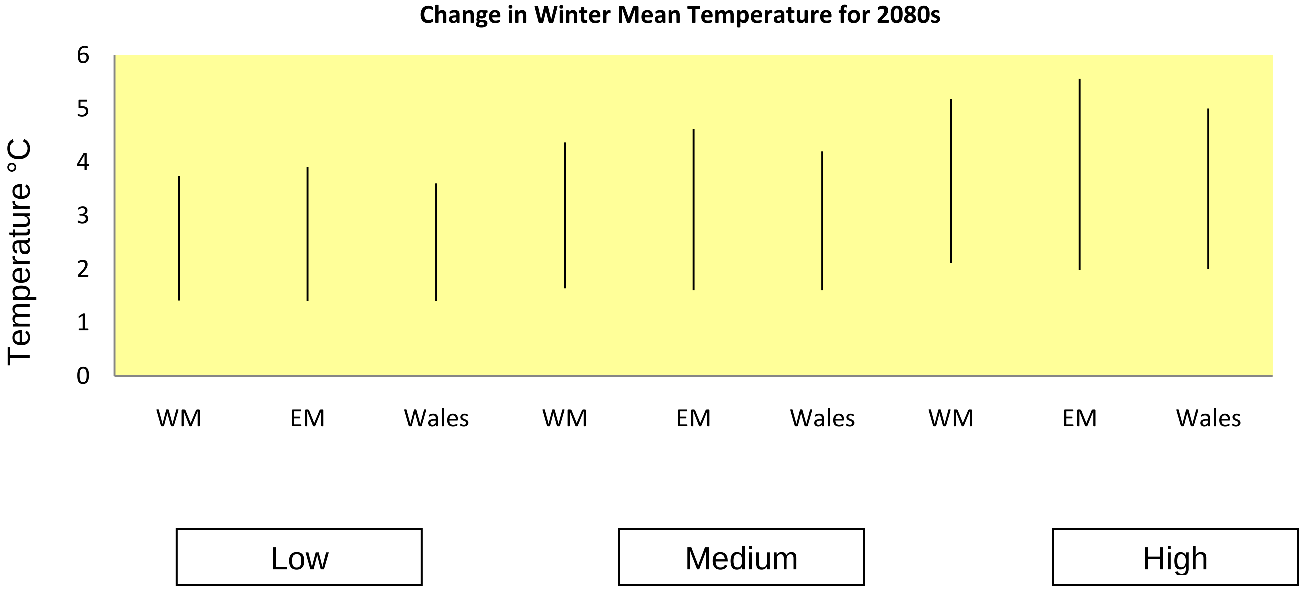
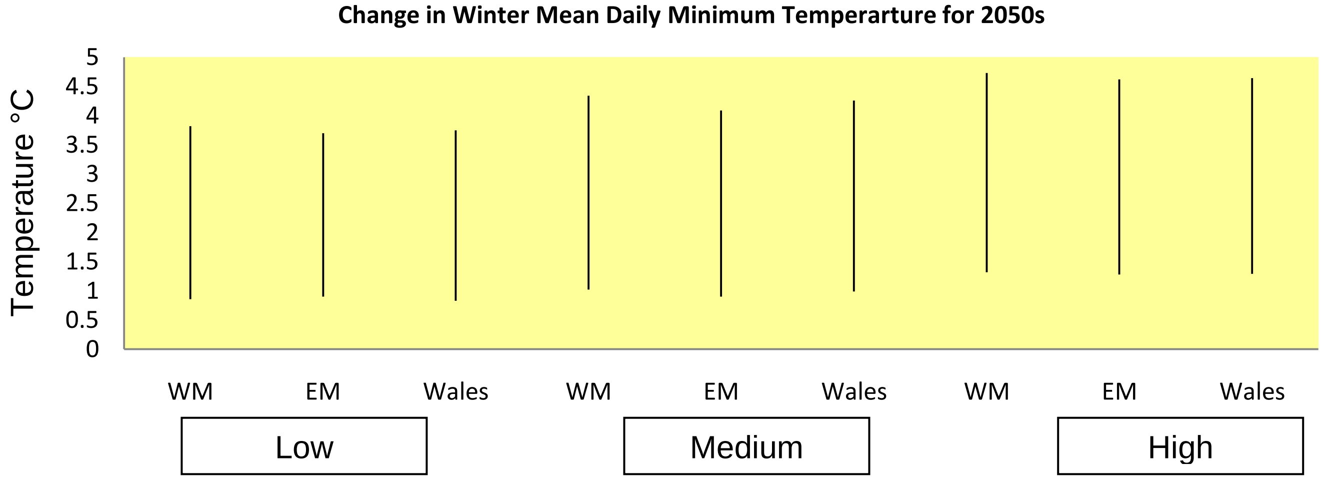


Figure A2.2 Winter mean daily minimum temperature

		Emissions Scenario								
2050s		Low			Medium			High		
Region		WM	EM	Wales	WM	EM	Wales	WM	EM	Wales
Unlikely to be less than	°C	0.86	0.9	0.83	1.02	0.9	0.99	1.32	1.28	1.29
Best Central Estimate	°C	2.22	2.16	2.18	2.54	2.4	2.49	2.88	2.83	2.82
Unlikely to be more than	°C	3.82	3.7	3.75	4.34	4.09	4.26	4.73	4.62	4.64



		Emissions Scenario								
2080s		Low			Medium			High		
Region		WM	EM	Wales	WM	EM	Wales	WM	EM	Wales
Unlikely to be less than	°C	1.3	1.19	1.28	1.48	1.44	1.45	1.89	1.73	1.85
Best Central Estimate	°C	2.96	2.84	2.9	3.53	3.39	3.47	4.28	4.13	4.2
Unlikely to be more than	°C	4.95	4.76	4.86	6.02	5.65	5.91	7.19	6.96	7.1

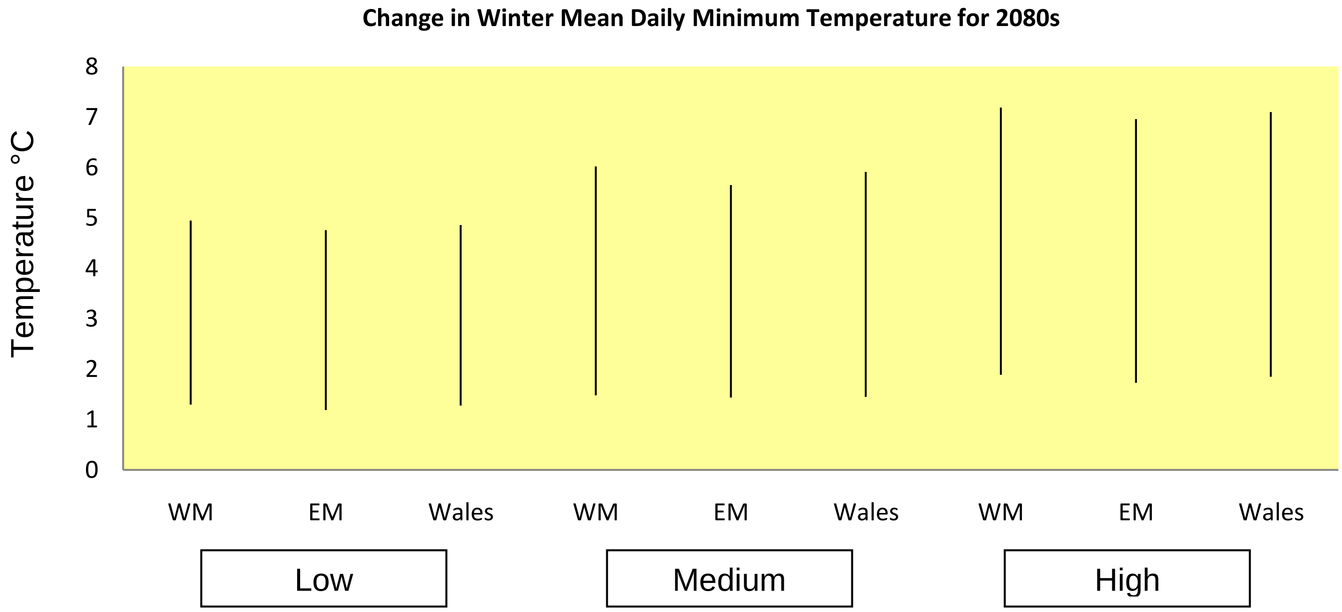
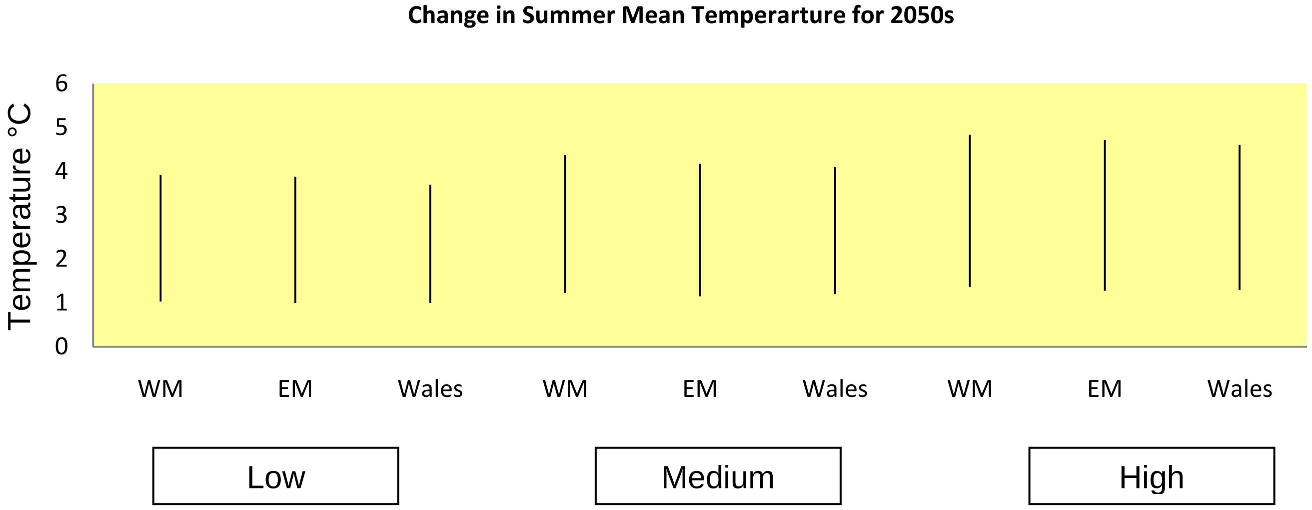


Figure A2.3 Summer mean temperature

2050s		Emissions Scenario								
		Low			Medium			High		
Region		WM	EM	Wales	WM	EM	Wales	WM	EM	Wales
Unlikely to be less than	°C	1.03	1	1	1.23	1.15	1.2	1.36	1.28	1.3
Best Central Estimate	°C	2.35	2.3	2.2	2.62	2.48	2.5	2.93	2.79	2.8
Unlikely to be more than	°C	3.92	3.88	3.7	4.37	4.17	4.1	4.84	4.71	4.6



2080s		Emissions Scenario								
		Low			Medium			High		
Region		WM	EM	Wales	WM	EM	Wales	WM	EM	Wales
Unlikely to be less than	°C	1.28	1.23	1.2	2	1.84	1.9	2.58	2.34	2.4
Best Central Estimate	°C	2.8	2.68	2.1	3.75	3.52	3.5	4.74	4.43	4.5
Unlikely to be more than	°C	4.73	4.58	4.5	6.1	5.8	5.8	7.54	7.28	7.1

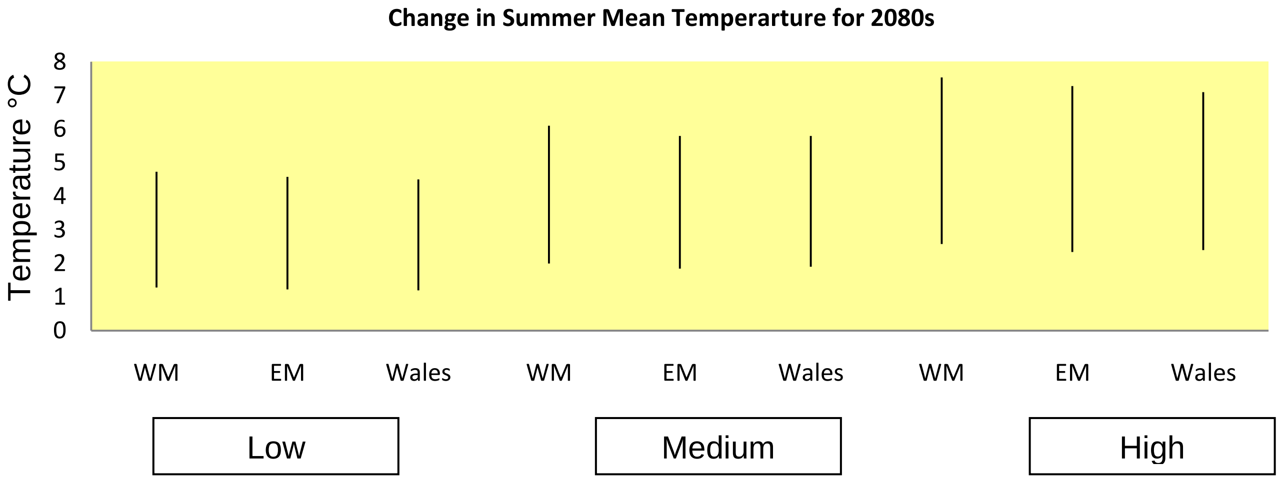
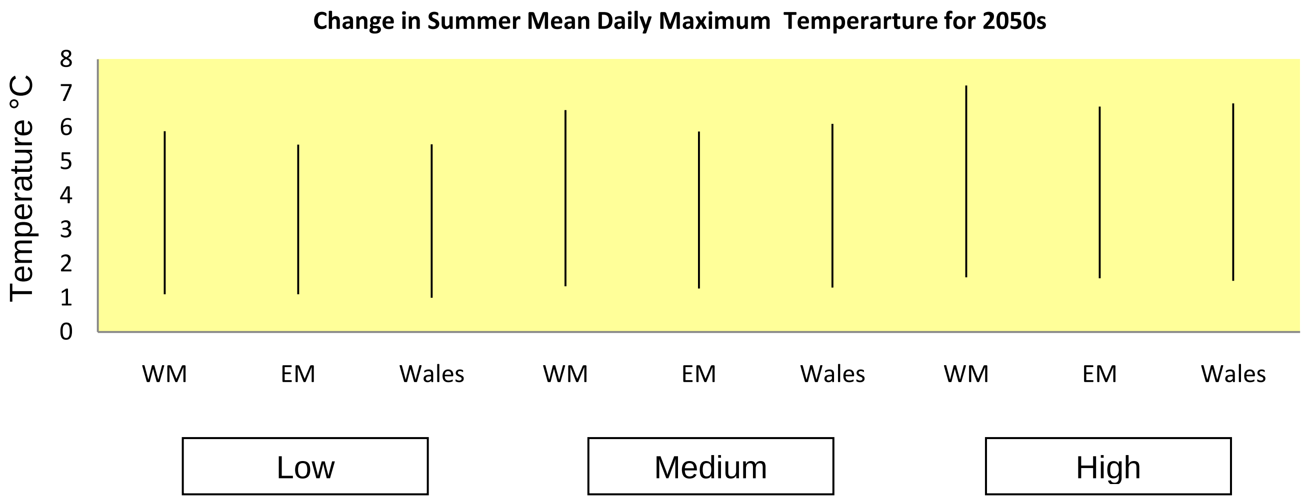


Figure A2.4 Summer mean daily maximum temperature

		Emissions Scenario								
2050s		Low			Medium			High		
Region		WM	EM	Wales	WM	EM	Wales	WM	EM	Wales
Unlikely to be less than	°C	1.1	1.1	1	1.34	1.27	1.3	1.6	1.57	1.5
Best Central Estimate	°C	3.27	3.11	3	3.64	3.33	3.4	4.13	3.83	3.8
Unlikely to be more than	°C	5.89	5.49	5.5	6.51	5.88	6.1	7.23	6.61	6.7



		Emissions Scenario								
2080s		Low			Medium			High		
Region		WM	EM	Wales	WM	EM	Wales	WM	EM	Wales
Unlikely to be less than	°C	1.24	1.22	1.2	2.08	2.02	1.9	2.9	2.72	2.7
Best Central Estimate	°C	3.92	3.65	3.7	5.18	4.73	4.8	6.58	6.04	6.1
Unlikely to be more than	°C	7.26	6.64	6.8	9.19	8.25	8.6	11.34	10.32	10.6

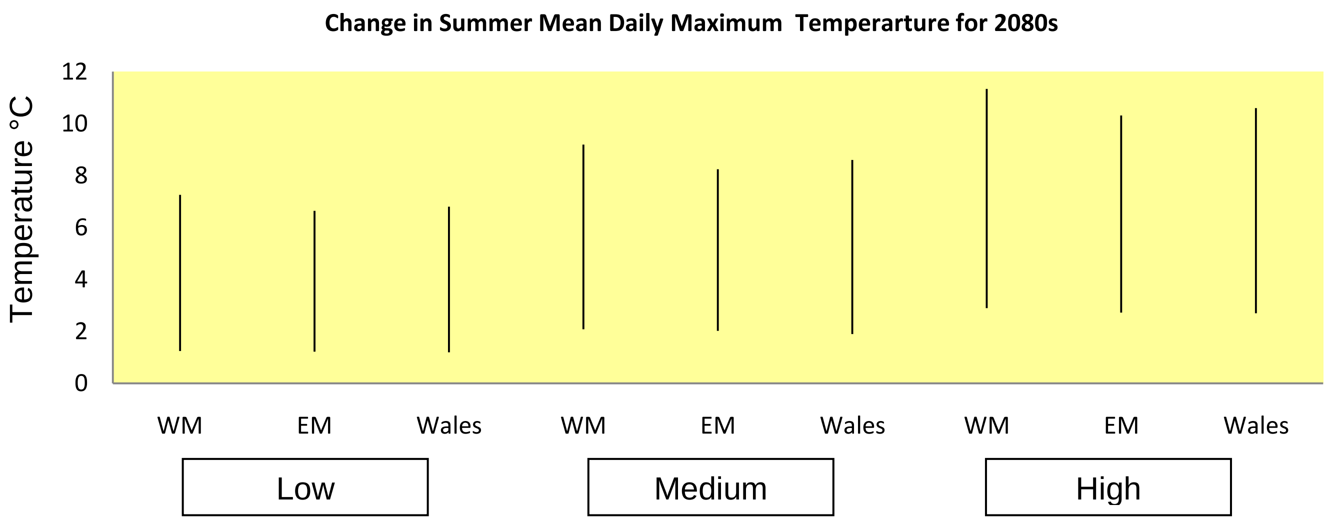
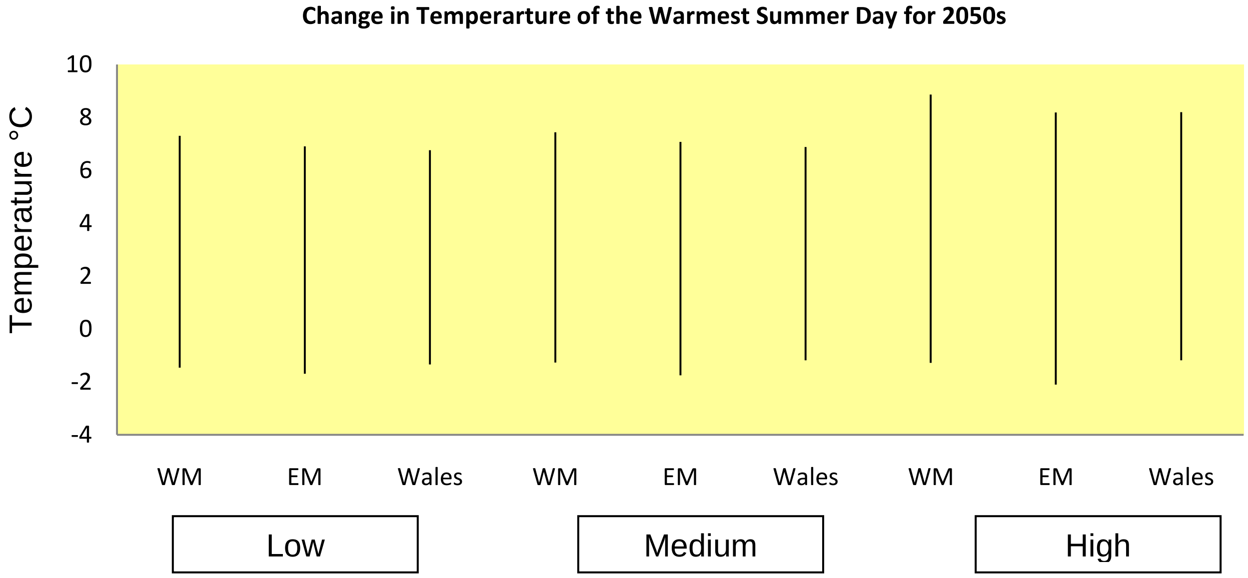


Figure A2.5 Warmest summer day temperature

		Emissions Scenario								
2050s		Low			Medium			High		
Region		WM	EM	Wales	WM	EM	Wales	WM	EM	Wales
Unlikely to be less than	°C	-1.5	-1.7	-1.3	-1.3	-1.8	-1.2	-1.3	-2.1	-1.2
Best Central Estimate	°C	2.55	2.37	2.36	2.56	2.26	2.37	3.27	2.67	3.02
Unlikely to be more than	°C	7.3	6.91	6.76	7.44	7.08	6.88	8.86	8.19	8.2



		Emissions Scenario								
2080s		Low			Medium			High		
Region		WM	EM	Wales	WM	EM	Wales	WM	EM	Wales
Unlikely to be less than	°C	-1.8	-2.4	-1.6	-1.6	-2.2	-1.5	-1.3	-2.3	-1.2
Best Central Estimate	°C	2.56	2.38	2.37	3.39	2.94	3.13	4.42	3.88	4.09
Unlikely to be more than	°C	8.14	7.9	7.53	10.1	9.45	9.34	12.6	11.7	11.6

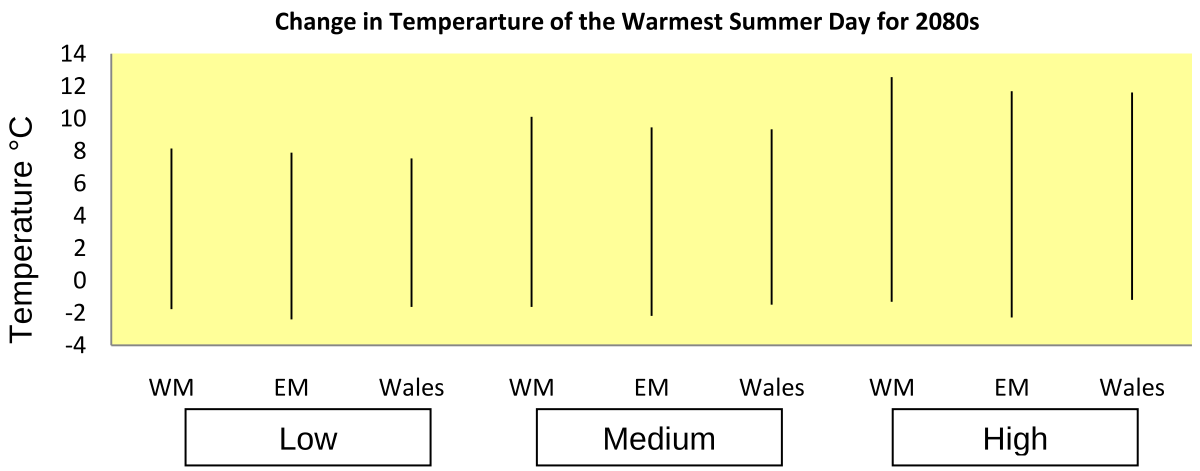
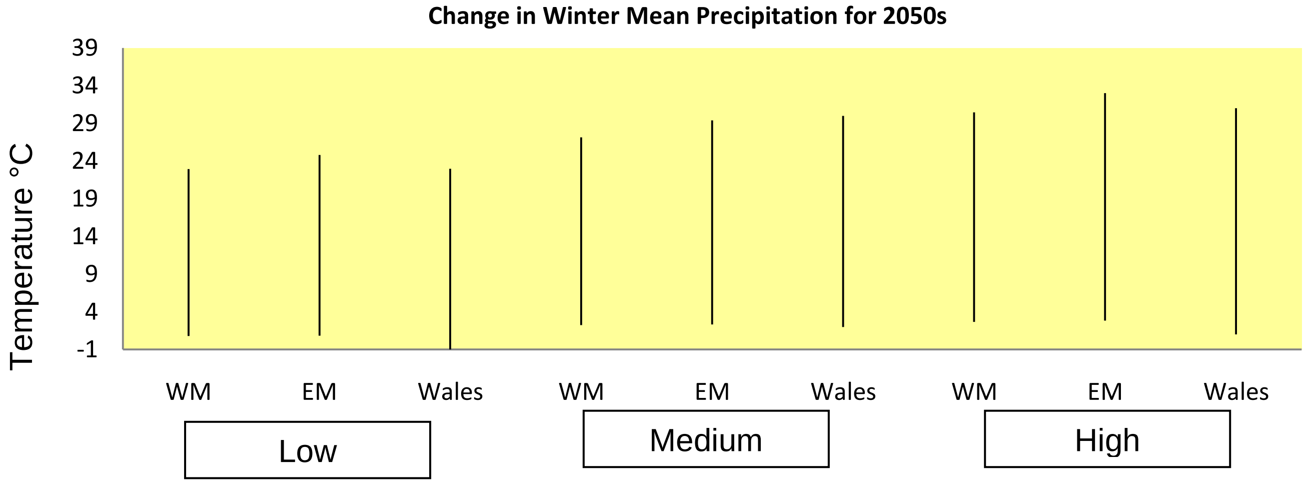


Figure A2.6 Winter mean precipitation

		Emissions Scenario								
2050s		Low			Medium			High		
Region		WM	EM	Wales	WM	EM	Wales	WM	EM	Wales
Unlikely to be less than	%	0.81	0.83	-1	2.23	2.35	2	2.66	2.82	1
Best Central Estimate	%	10.39	11.18	9	12.79	13.77	14	14.45	15.56	13
Unlikely to be more than	%	22.92	24.8	23	27.15	29.4	30	30.47	33.02	31



		Emissions Scenario								
2080s		Low			Medium			High		
Region		WM	EM	Wales	WM	EM	Wales	WM	EM	Wales
Unlikely to be less than	%	3.18	3.37	5	3.22	3.42	4	5.79	6.19	7
Best Central Estimate	%	14.11	15.16	16	17.22	18.56	19	23.02	24.86	26
Unlikely to be more than	%	29.85	32.33	33	38.05	41.3	42	49.58	53.98	57

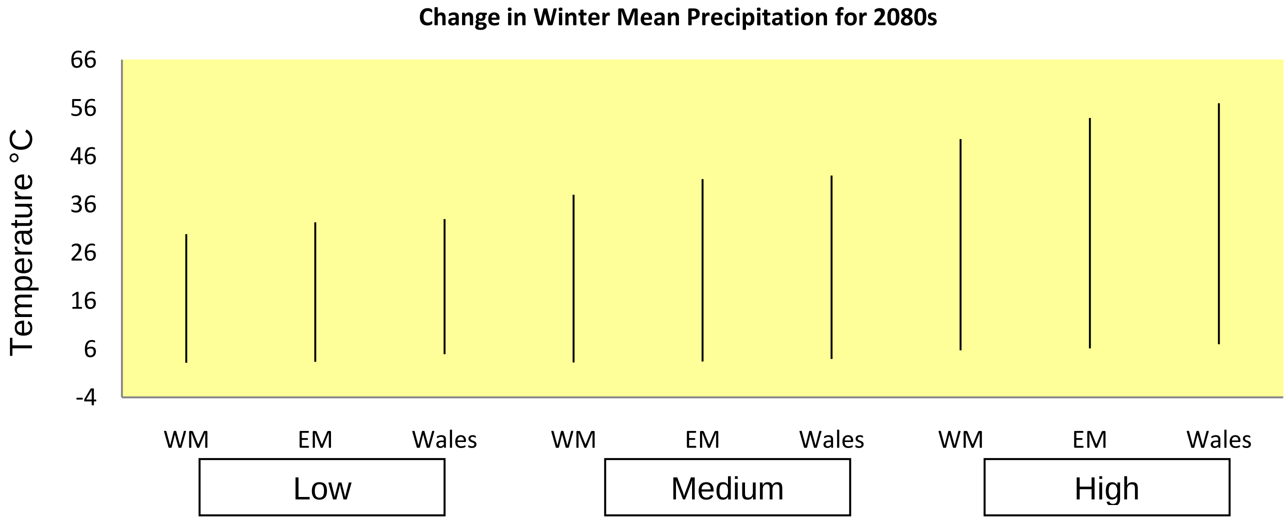
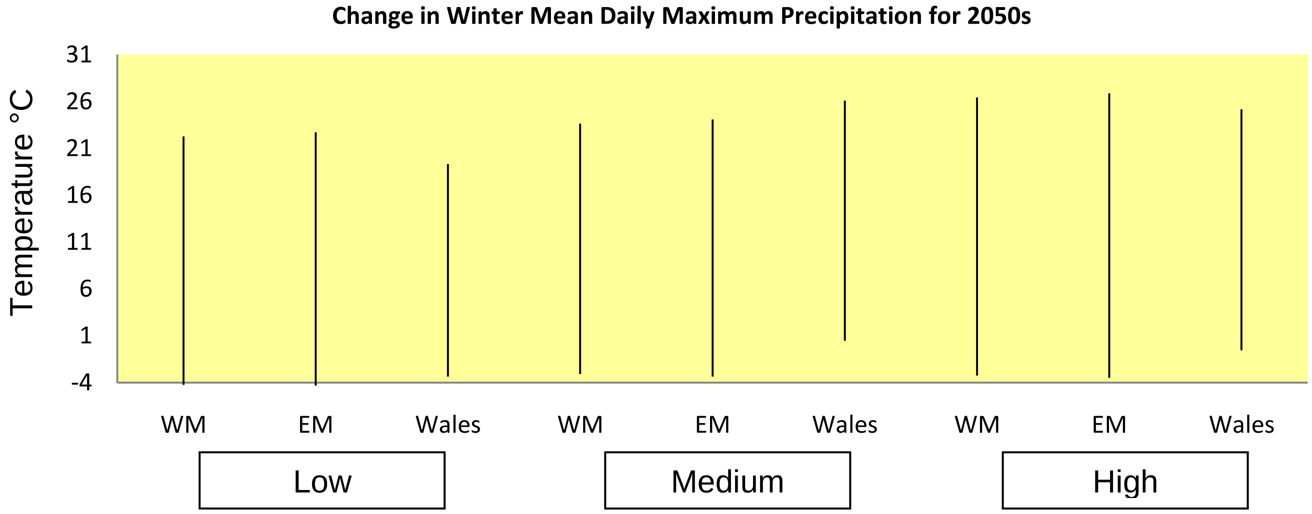


Figure A2.7 Winter mean daily maximum precipitation

		Emissions Scenario								
2050s		Low			Medium			High		
Region		WM	EM	Wales	WM	EM	Wales	WM	EM	Wales
Unlikely to be less than	%	-4.25	-4.53	-3.35	-3.09	-3.37	0.476	-3.25	-3.51	-0.579
Best Central Estimate	%	7.93	7.97	7.012	9.11	9.16	11.912	10.19	10.24	10.759
Unlikely to be more than	%	22.28	22.72	19.33	23.63	24.07	26.11	26.43	26.88	25.18



		Emissions Scenario								
2080s		Low			Medium			High		
Region		WM	EM	Wales	WM	EM	Wales	WM	EM	Wales
Unlikely to be less than	%	-1.26	1.53	-0.269	-0.42	-0.67	-0.771	0.02	-0.19	3.68
Best Central Estimate	%	12.19	12.25	11.41	13.38	13.45	14.35	17.49	17.57	19.315
Unlikely to be more than	%	28.71	29.18	25.986	30.8	31.27	32.677	40.46	40.96	41.856

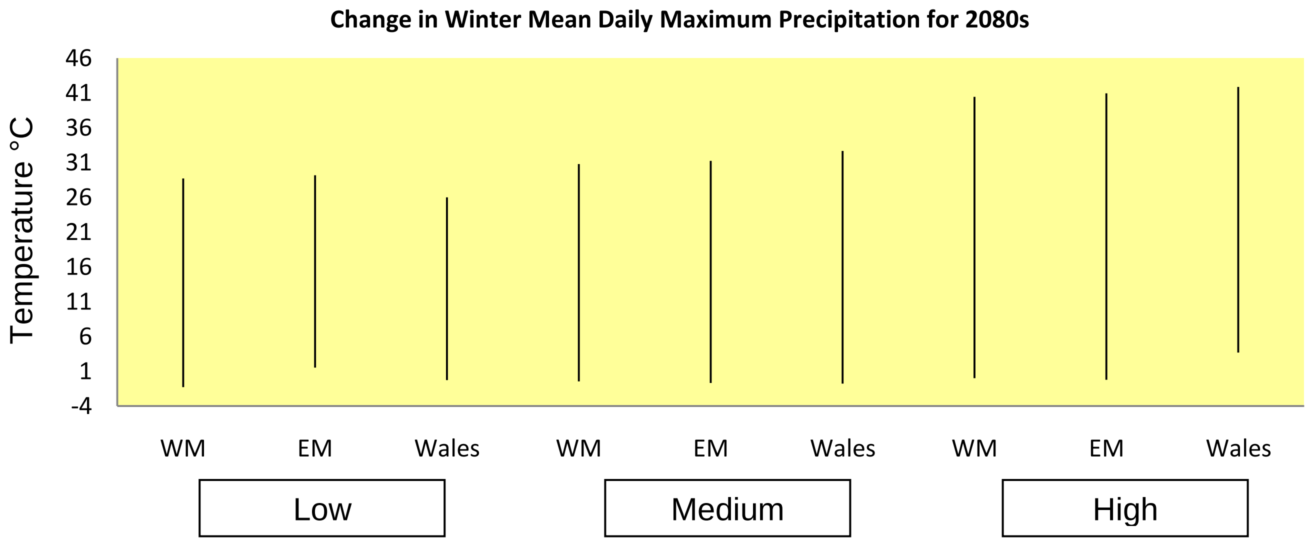
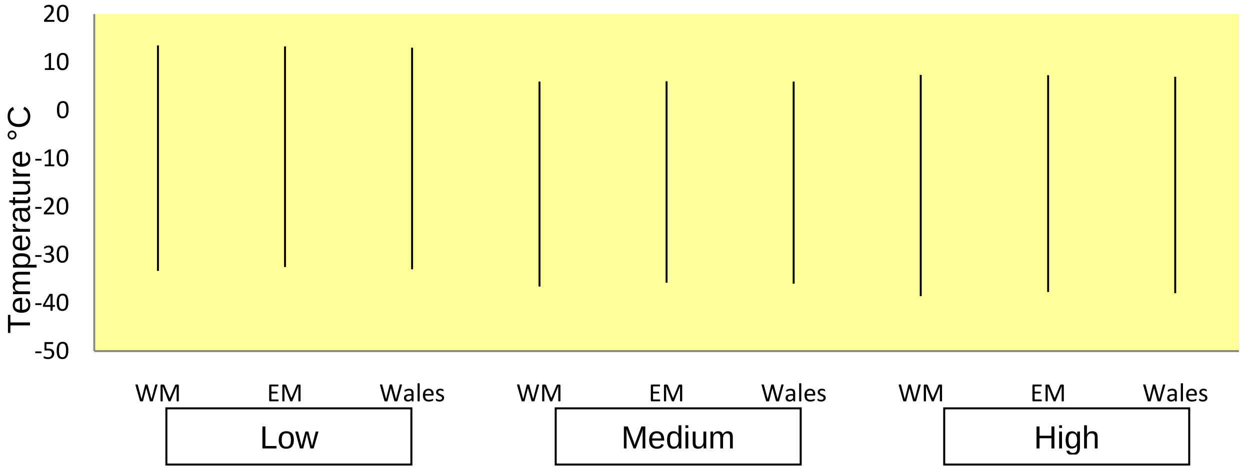


Figure A2.8 Summer mean precipitation

2050s		Emissions Scenario								
		Low			Medium			High		
Region		WM	EM	Wales	WM	EM	Wales	WM	EM	Wales
Unlikely to be less than	%	-33.32	-32.55	-33	-36.61	-35.78	-36	-38.61	-37.72	-38
Best Central Estimate	%	-12.08	-11.71	-12	-16.69	-16.2	-17	-17.08	-16.57	-17
Unlikely to be more than	%	13.5	13.27	13	6	6.04	6	7.34	7.32	7

Change in Summer Mean Precipitation for 2050s



2080s		Emissions Scenario								
		Low			Medium			High		
Region		WM	EM	Wales	WM	EM	Wales	WM	EM	Wales
Unlikely to be less than	%	-34.97	-34.16	-35	-43.5	-42.52	-43	-51.55	-50.44	-51
Best Central Estimate	%	-13.37	-12.97	-13	-20.44	-19.85	-20	-25.79	-25.06	-26
Unlikely to be more than	%	10.98	10.84	11	5.71	5.72	5	3.98	4.01	4

Change in Summer Mean Precipitation for 2080s

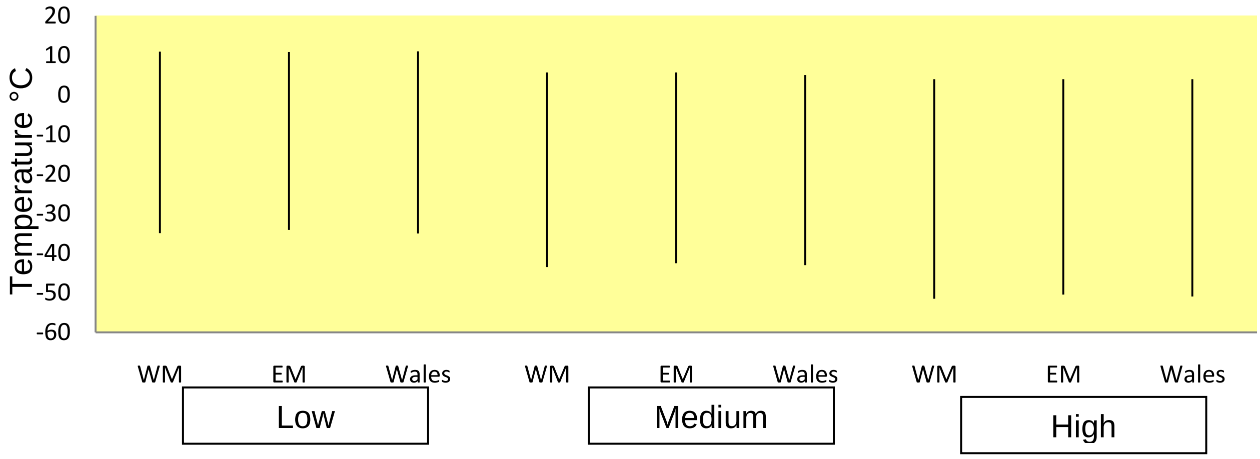
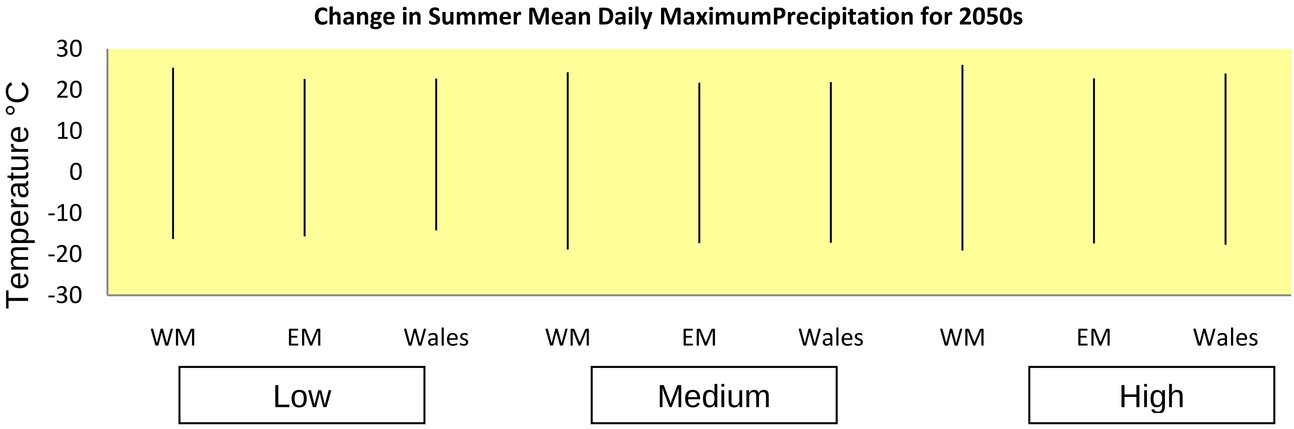


Figure A2.9 Summer mean daily maximum precipitation

2050s		Emissions Scenario								
		Low			Medium			High		
Region		WM	EM	Wales	WM	EM	Wales	WM	EM	Wales
Unlikely to be less than	%	-16.3	-15.6	-14.2	-18.81	-17.3	-17.2	-19.1	-17.4	-17.7
Best Central Estimate	%	2.5	1.7	2.8	0.6	0.4	0.7	1.2	0.78	1.4
Unlikely to be more than	%	25.4	22.7	22.8	24.3	21.6	21.9	26.1	22.9	24.1



2080s		Emissions Scenario								
		Low			Medium			High		
Region		WM	EM	Wales	WM	EM	Wales	WM	EM	Wales
Unlikely to be less than	%	-15.5	-15.1	-13.4	-18.9	-17.2	-17.5	-22.3	-19.18	-21.7
Best Central Estimate	%	3.9	2.6	4.4	2.0	1.3	2.4	2.1	1.3	2.4
Unlikely to be more than	%	27.5	24.1	25.0	27.6	23.8	25.6	32.6	26.62	31.8

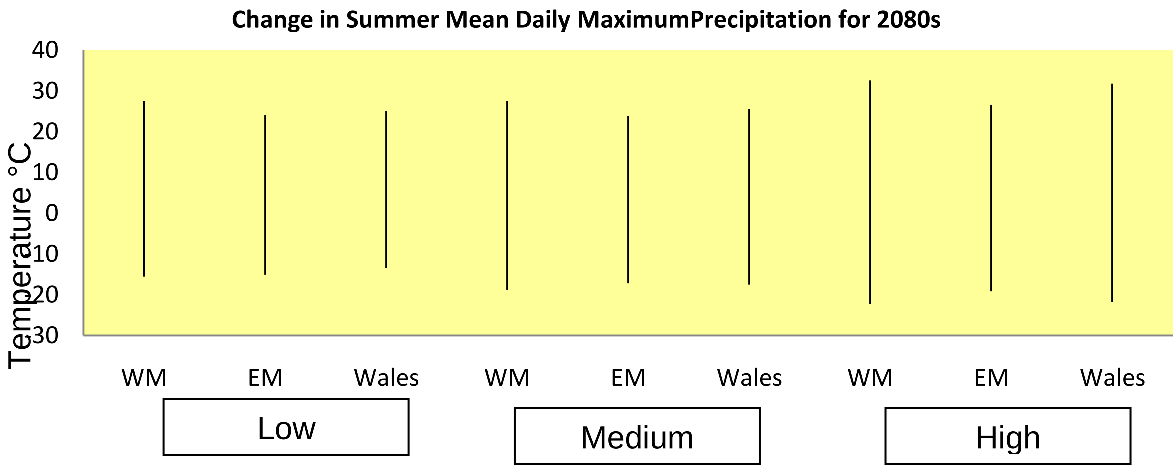
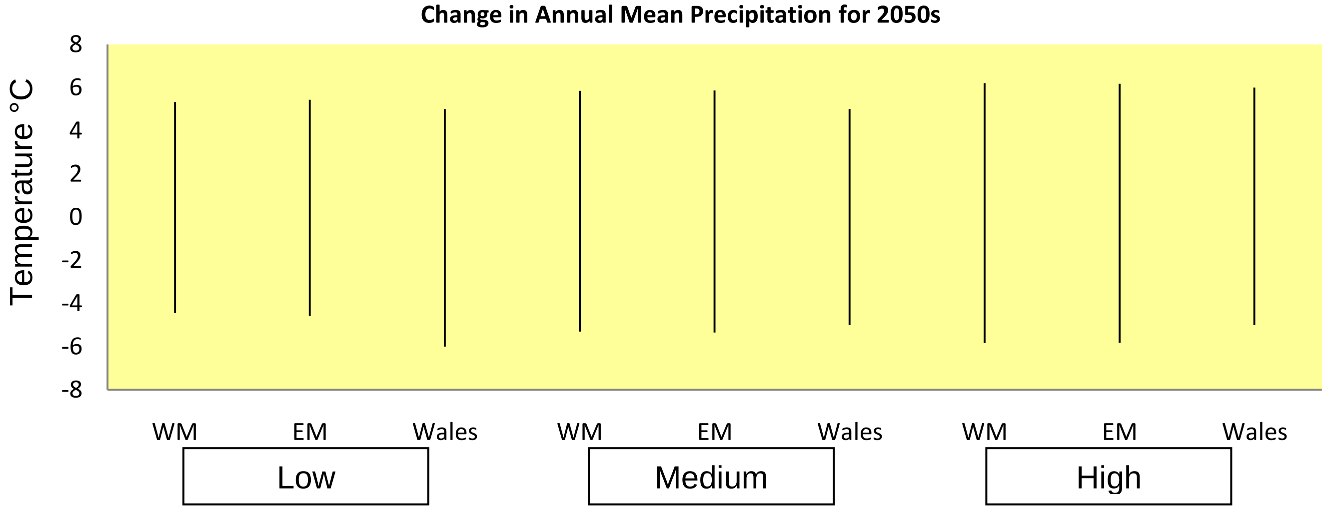


Figure A2.10 Annual precipitation

2050s		Emissions Scenario								
		Low			Medium			High		
Region		WM	EM	Wales	WM	EM	Wales	WM	EM	Wales
Unlikely to be less than	%	-4.44	-4.57	-6	-5.31	-5.35	-5	-5.84	-5.82	-5
Best Central Estimate	%	0.32	0.3	-1	0.09	0.08	0	-0.03	-0.03	0
Unlikely to be more than	%	5.33	5.44	5	5.85	5.87	5	6.2	6.18	6



2080s		Emissions Scenario								
		Low			Medium			High		
Region		WM	EM	Wales	WM	EM	Wales	WM	EM	Wales
Unlikely to be less than	%	-3.02	-3.25	-5	-4.99	-5.04	-6	-6.95	-6.78	-8
Best Central Estimate	%	1.72	1.6	0	0.54	0.51	0	0.67	0.62	0
Unlikely to be more than	%	6.77	6.81	6	6.55	6.52	6	9.13	8.83	8.83

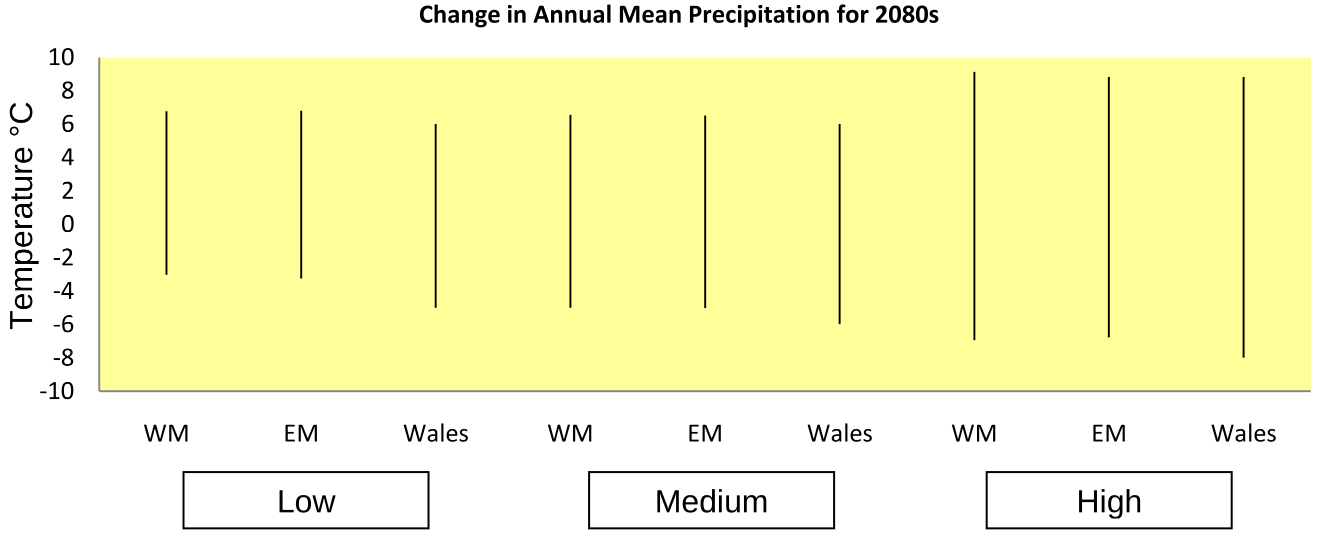
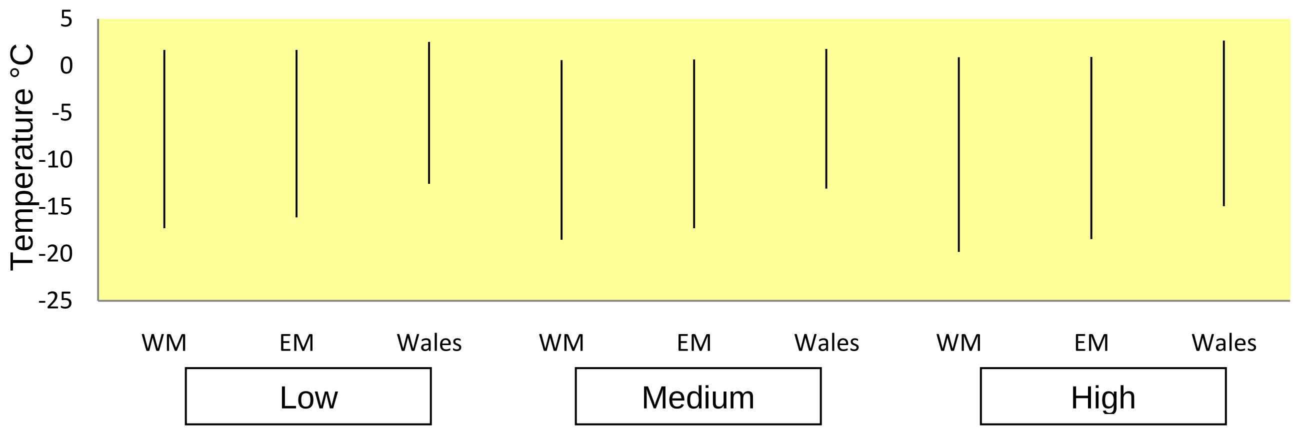


Figure A2.11 Summer Cloud Cover

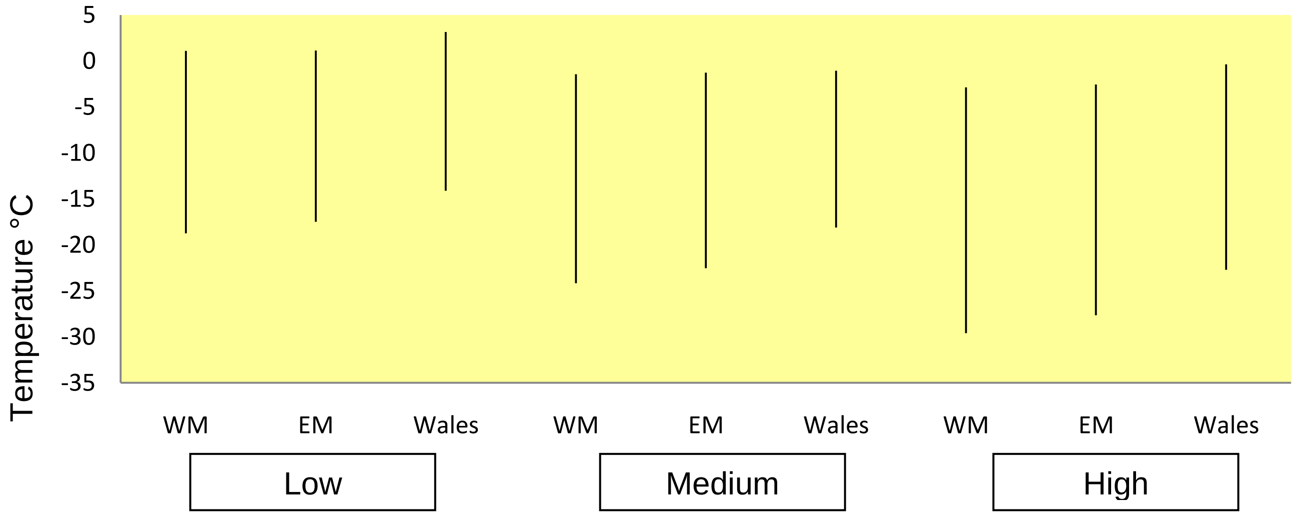
2050s		Emissions Scenario								
		Low			Medium			High		
Region		WM	EM	Wales	WM	EM	Wales	WM	EM	Wales
Unlikely to be less than	%	-17.29	-16.12	-12.57	-18.53	-17.28	-13.07	-19.8	-18.46	-14.94
Best Central Estimate	%	-7.91	-7.31	-5.06	-9.04	-8.36	-5.59	-9.63	-8.9	-6.09
Unlikely to be more than	%	1.7	1.7	2.56	0.618	0.68	1.8	0.9	0.94	2.69

Change in Summer Colud Cover for 2050s



2080s		Emissions Scenario								
		Low			Medium			High		
Region		WM	EM	Wales	WM	EM	Wales	WM	EM	Wales
Unlikely to be less than	%	-18.73	-17.47	-14.09	-24.16	-22.54	-18.1	-29.6	-27.66	-22.7
Best Central Estimate	%	-8.7	-8.04	-5.47	-12.79	-11.84	-8.48	-16.52	-15.32	-11.27
Unlikely to be more than	%	1.11	1.138	3.15	-1.45	-1.25	-1.07	-2.87	-2.56	-0.37

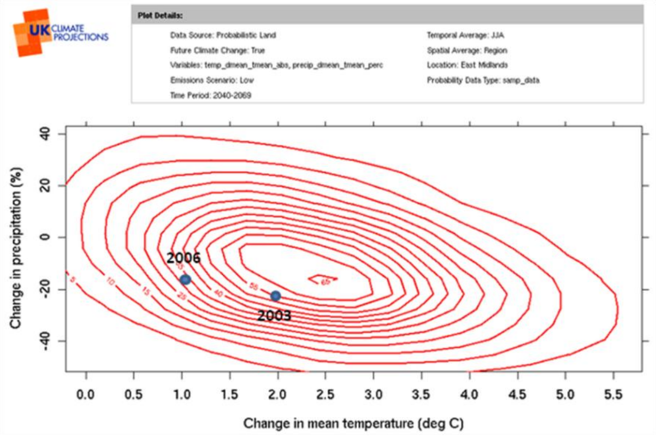
Change in Summer Cloud Cover for 2080s



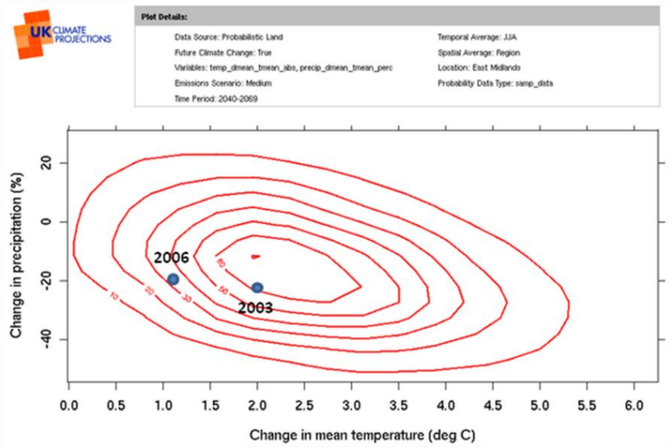
A2.1 Joint probability plots for the East Midlands and West Midlands and Wales all emissions scenarios, 2050s and 2080s

The following figures show the change in summer mean temperature (°C) vs. the change in summer precipitation (%). As discussed in Chapter 3 we plotted the hot and dry periods of 2003 and 2006 on these charts to help us determine the scale of future changes and the possible thresholds at which our operations would be placed under stress.

Figure A2.12 East Midlands, scenario: 2050s
Low emissions



Medium emissions



High emissions

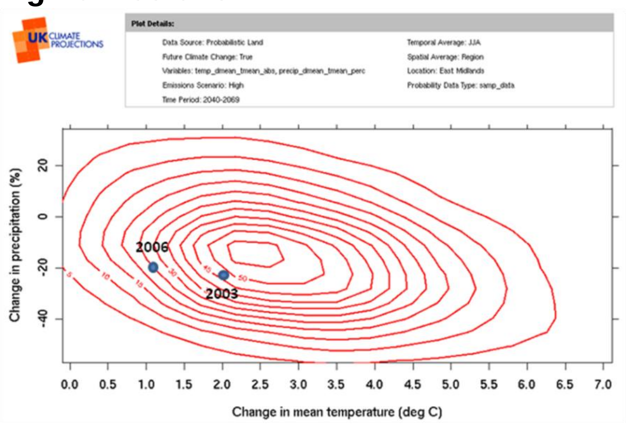
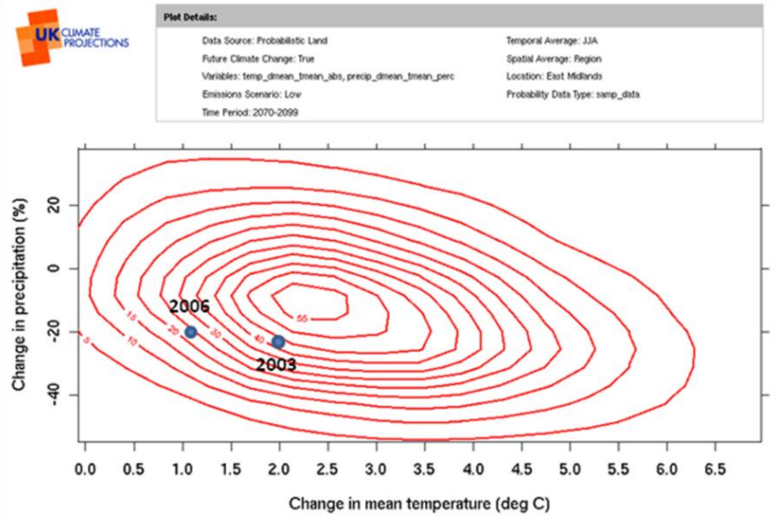
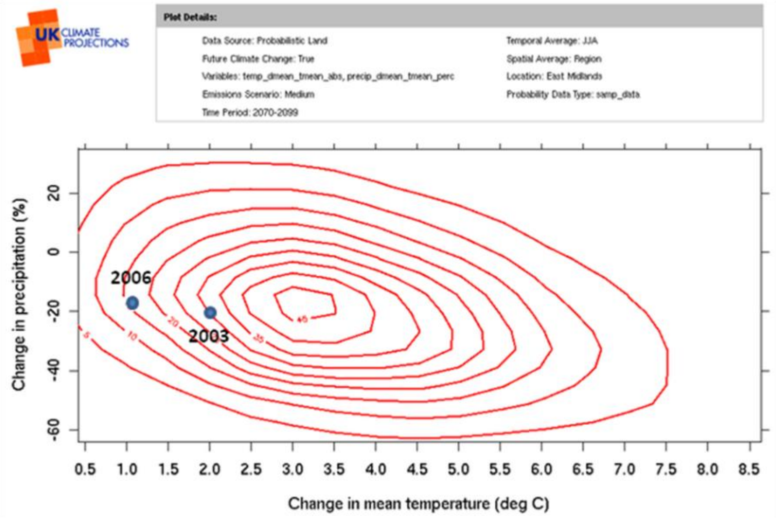


Figure A2.13 East Midlands, scenario: 2080s

Low emissions



Medium emissions



High emissions

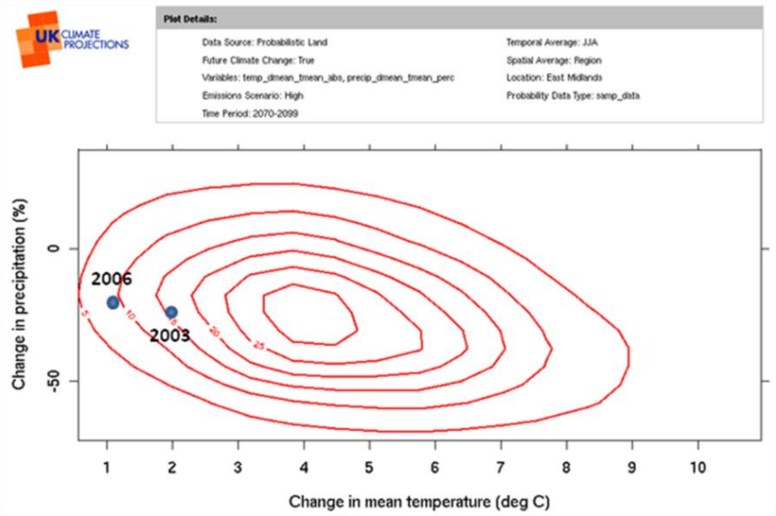
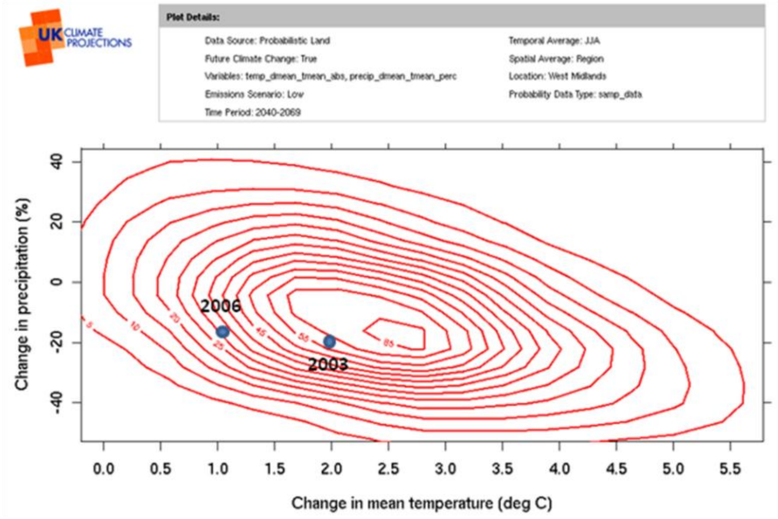
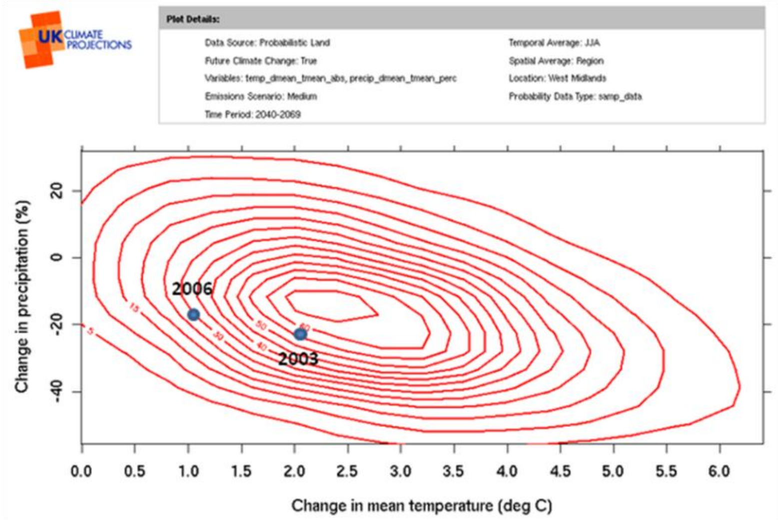


Figure A2.14 West Midlands, scenario: 2050s
Low emissions



Medium emissions



High emissions

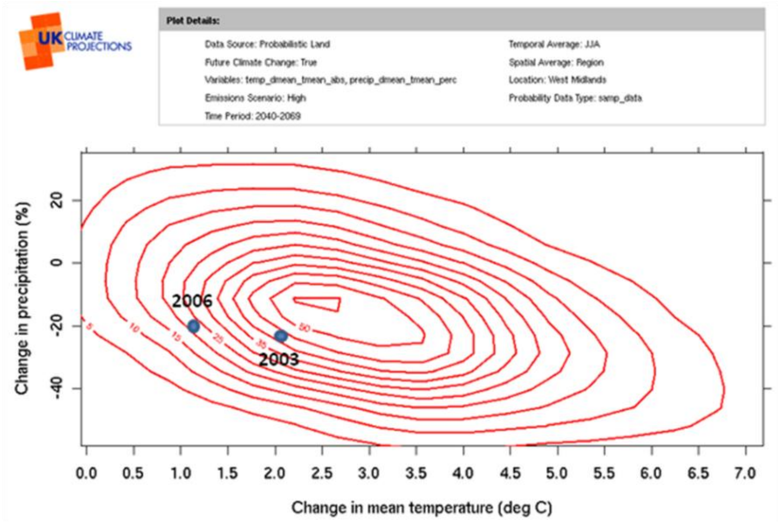
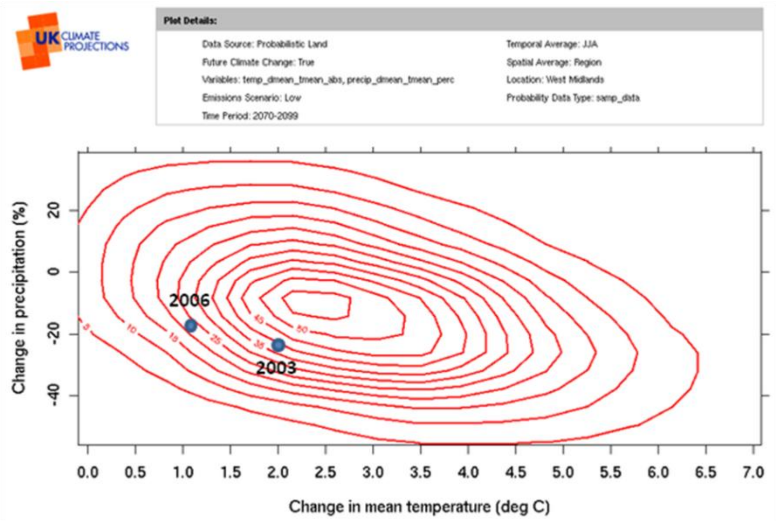
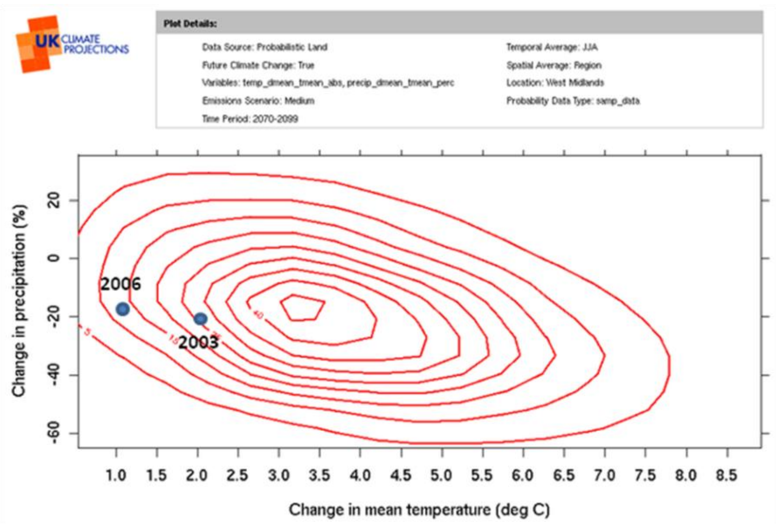


Figure A2.15 West Midlands, scenario: 2080s
Low emissions



Medium emissions



High emissions

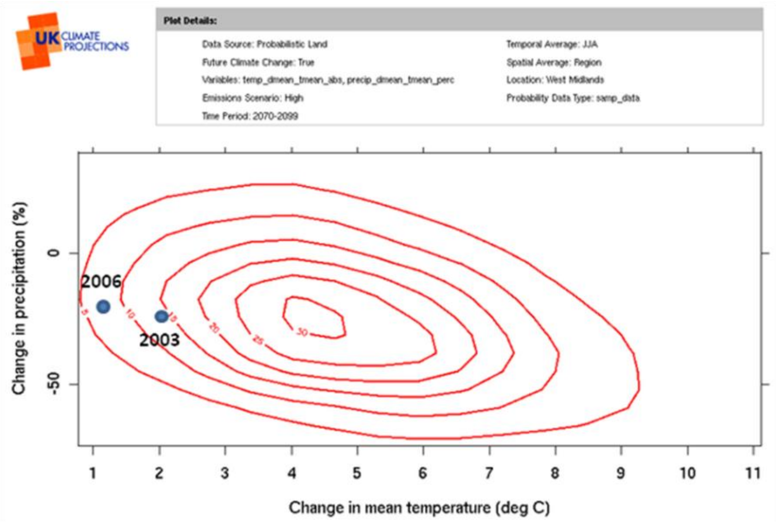
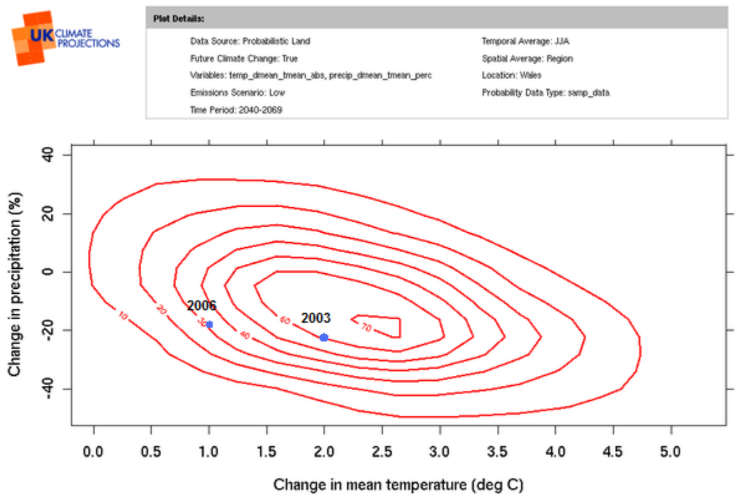
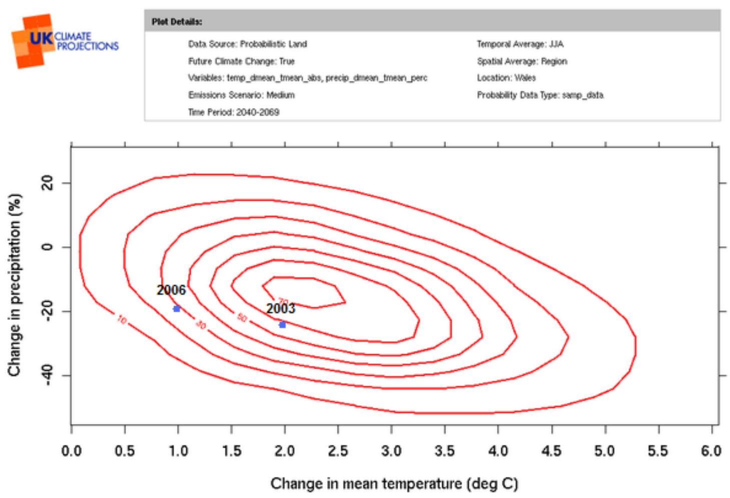


Figure A2.16 Wales, Scenario: 2050
Low emissions



Medium emissions



High emissions

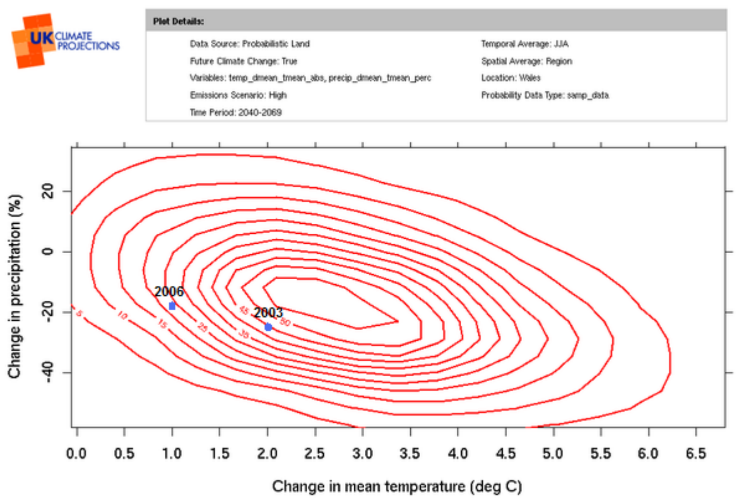
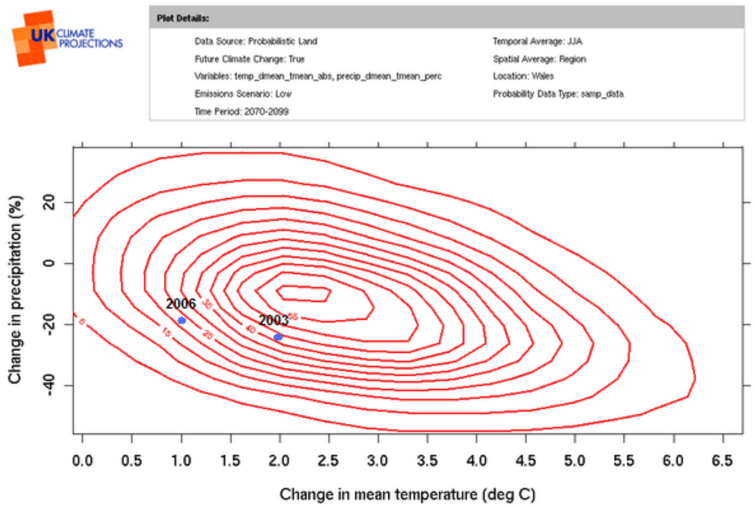
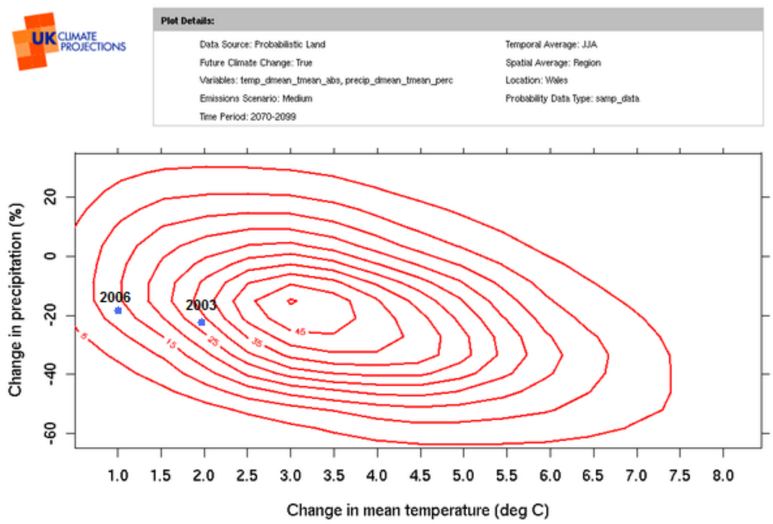


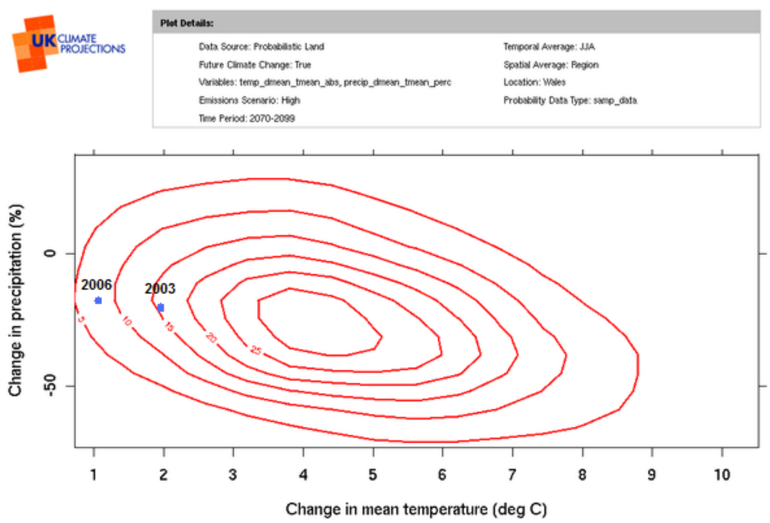
Figure A2.16 Wales, Scenario: 2080
Low emissions



Medium emissions



High emissions



A2.2 Critical thresholds

It has not been possible to define simple trigger levels for each variable either because it is the in-combination effects of the climate change variables that pose the most significant impact or due to a lack of historical data. We could not determine any critical thresholds for support services or waste water.

A2.2.1 Critical threshold for Water Services

In the absence of simple thresholds for the individual variables, we have used past events to understand the implications of the climate change scenarios for future water supply. For example, high domestic demand, is driven by both low precipitation and high temperatures, which combine to produce high Soil Moisture Deficit levels. Dry soils and warm weather trigger higher demand as water consumers begin watering their gardens. Under extreme summer temperature conditions customers' demand can dramatically increase, and at the same time our water resources can be under stress due to low precipitation.

Figure A2.17 shows the record of total demand for water across our region since 1989, while Figure A2.18 shows a record of summer precipitation and temperature over that period from a weather station in our region.

The long term trend in annual average demand for water is a declining one, but with periods of high demand during years with extreme hot and dry summers. For example, we recorded a record high demand for water during 1995-96, which was a year of high summer temperatures and extremely low precipitation. We also experienced a significant peak week demand for water in summer 2003 and summer 2006, which were both years with a high summer peak temperature. Our experience of managing water supply operations during years with extreme weather conditions gives us a strong foundation for planning to minimise the impacts that climate change would have on water supply.

Figure A2.17 Severn Trent Water total water into supply since 1989

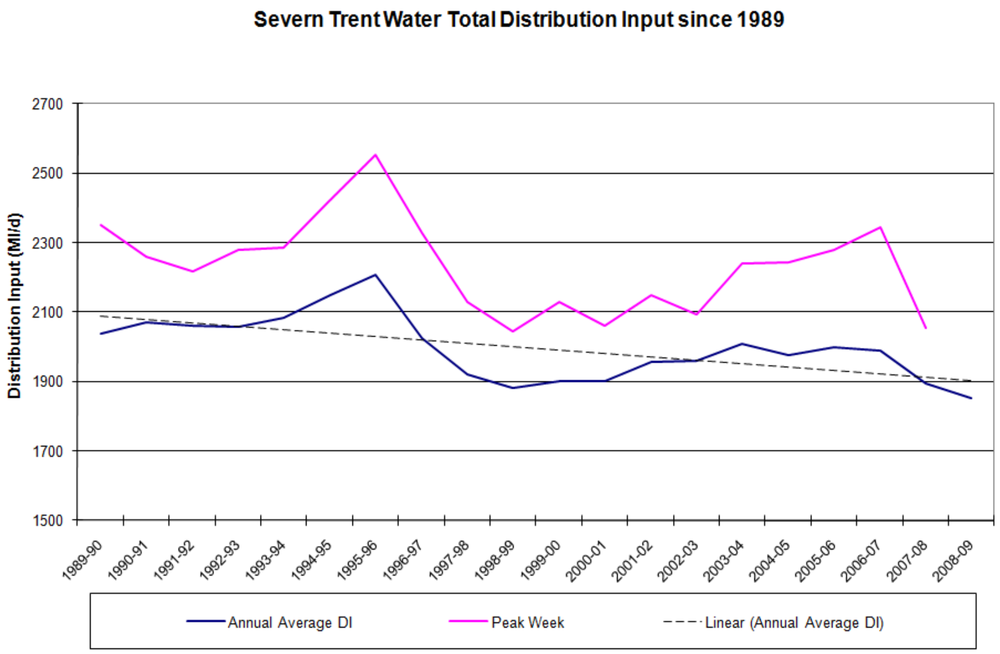
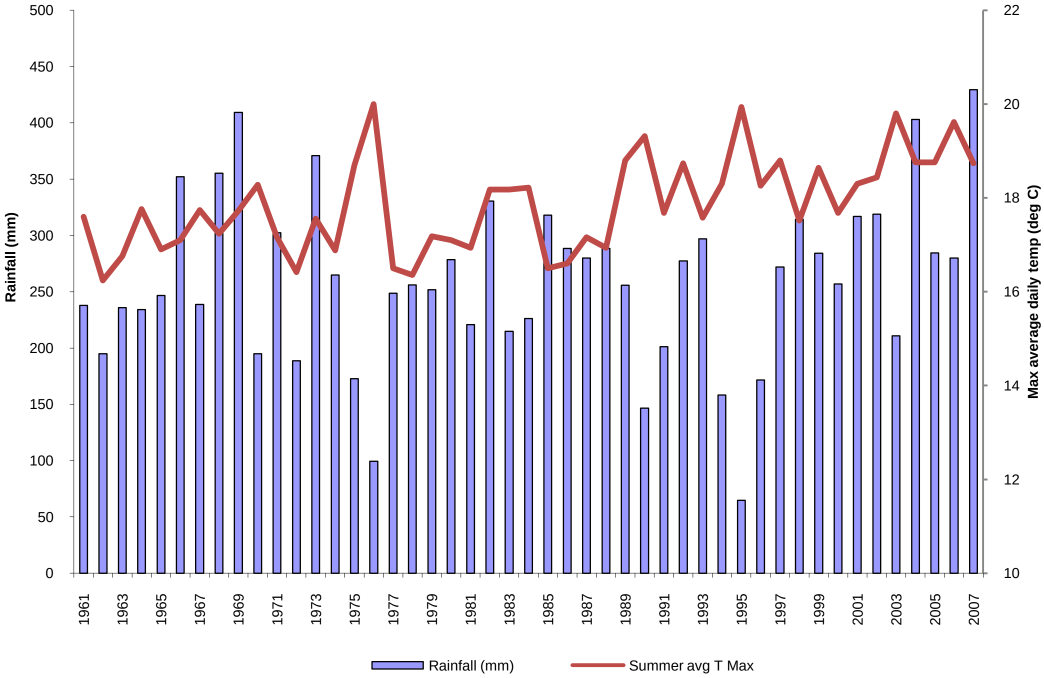


Figure A2.18 April to August cumulative precipitation and maximum average daily temperature at Sutton Bonnington, Leicestershire.



We have analysed the data for the in-combination effects of the climate change variable for summer by the 2050s and 2080s, looking specifically at the likelihood of increasing daily maximum summer temperatures alongside the likelihood of decreasing mean summer precipitation.

As described, we identified that 2003 and 2006 are examples of two recent years when high summer temperatures and low precipitation led to very extreme peak demand for water. We have plotted how the temperature and precipitation conditions in those years compare with the climate change projections on the joint probability plots. We have also included data for 1995, as this was the last drought year in our region.

The precipitation data shown in Table A2.1 is taken from the weekly updates we receive from the Environment Agency of areal precipitation across the Severn Trent Water region. The long term average figures were provided by the EA and cover the 1961 to 1990 Met Office standard period.

Table A2.1: Three-month average precipitation against long term average in the Severn Trent Water egion

Year	Jun to Aug monthly average (mm)	3 month average against LTA (%)
1995	17	-71
2003	46	-22
2006	48	-19

The temperature data, as shown in Table A2.2, covers the Central England area and is taken from the Hadley website. The long term average is the 1961 to 1990 Met Office standard period.

Table A2.2: Three-month average temperature against long term average in Central England

Year	Jun to Aug monthly average (°C)	3 month average against LTA (°C)
1995	17.4	+2.0
2003	17.3	+2.0
2006	17.2	+1.1

These data have been plotted on joint probability plots (Figure A2.19 and A2.20, below) to provide an indication of how past conditions which were known to put a stress on our water supply system compare to projections of what the future climate. The conditions experienced during our last drought year in 1995 are too severe to be plotted within the axis of the joint probability plots.

We have also identified key months which might be useful for comparison. The months with the greatest difference between monthly average and the LTA are shown in Table A2.3. However, the change in precipitation in these key months against the long term average does not fit the scale of the probability plots, implying that the actual conditions experienced during these months are still “extreme” when compared to the UKCP09 projections.

Table A2.3 Difference between key month actual and long term average in the Severn Trent Water region

Year	Key Month	Month average temperature against LTA (°C)	Month average precipitation against LTA (%)
1995	August	+3.4	-86.6
2003	August	+2.5	-74.6
2006	July	+3.7	-8.1

It should be noted that during July 2006 we experienced our highest peak monthly demand.

Figure A2.19 2050s Medium emissions – summer temperature vs summer precipitation

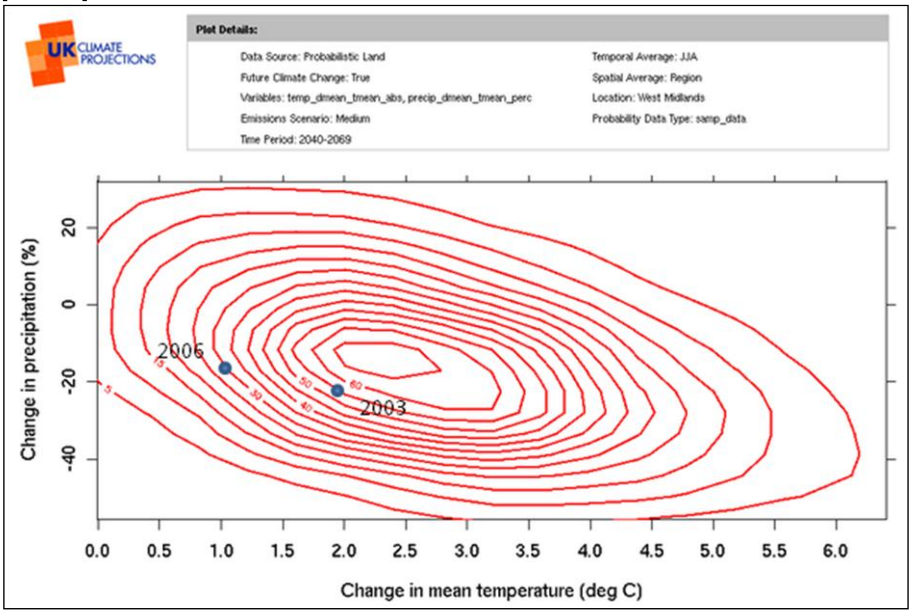
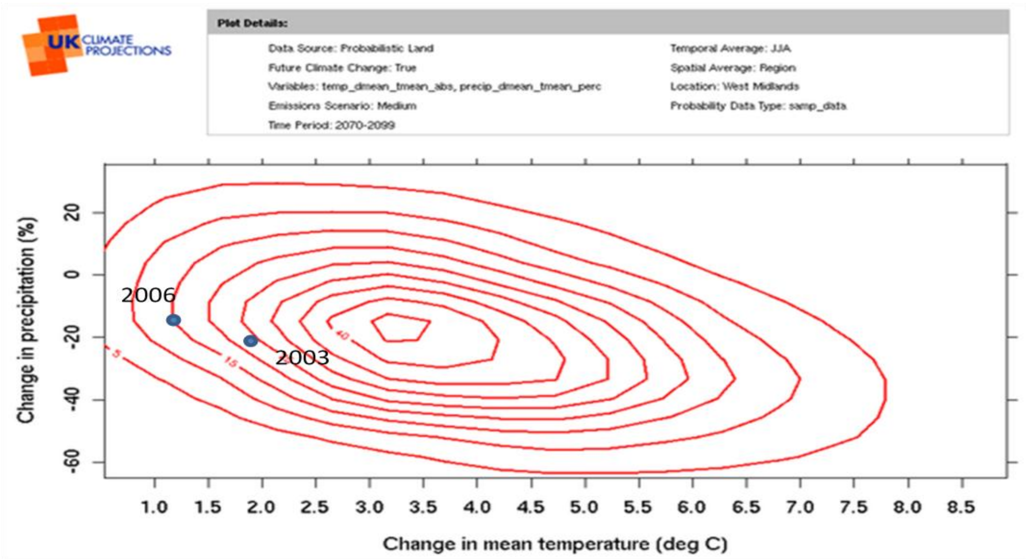


Figure A2.20 2080s Medium emissions – change in summer mean temperature vs. change in summer precipitation



The conditions experienced during 2003 are closest to the most likely projection of average temperature and precipitation under the 2050s medium emissions scenario. This implies that the extreme operating conditions experienced during 2003 could become closer to the normal operating conditions by the 2050s. Any extreme conditions in the 2050s will be more severe. The levels of precipitation in 2006 are close to UKCP09's most likely projections for both the 2050s and 2080s, however, temperatures are likely to increase across the summer to a level higher than experienced that year. This in-combination effect of hotter, drier summers would cause significant stress to our water supply and distribution infrastructure.

Appendix 3. Climate Change Risk Assessment

The following tables show the results of the climate change risk assessment carried out on water, waste water and support services.

A3.1 Water Services

Ref #	Climate Effect	Climate Impact	Consequence	Asset level 2	Asset level 3	T/O/N	Proximity vs. likelihood			Impact			Overall Risk Rating	Pedigree of Data	Confidence	Comments	Data/Evidence Source
							Proximity	Likelihood	Total	Population	Severity	Total					
Climate Driver: Increased Winter Precipitation																	
1	Wetter Winters (2050's Medium emissions)	Increased rate of groundwater recharge	More physical resource to abstract.	Water Resources	Borehole Pumping Stations	Opportunity	3	4	12	4	3	12	24	2	#M	This is an opportunity due to potential increased resource. Level 3 severity selected to reflect the positive impact. We would have to consider the regulatory licensing strategy as this may prevent use of additional resource if it became available.	(Senior Hydrogeologist- Impact of Climate Change on Deployable Output, report by Entec UK Limited 2009
	Wetter Winters (2050's High emissions)					Opportunity	3	4	12	4	3	12	24	2	#M		
	Wetter Winters (2080's Medium emissions)					Opportunity	3	4	12	4	3	12	24	2	#M		
	Wetter Winters (2080's High emissions)					Opportunity	3	4	12	4	3	12	24	2	#M		
2	Wetter Winters (2050's Medium emissions)	Increased pollution of aquifer due to leaching	Poorer quality raw water	Water treatment	Borehole Pumping Stations	Threat	3	4	12	3	4	12	24	2	#M	Increased leaching of Nitrates from bare fields in winter.	Senior Hydrogeologist Impact of Climate Change on Deployable Output, report by Entec UK Limited 2009
	Wetter Winters (2050's High emissions)					Threat	3	4	12	3	4	12	24	2	#M		
	Wetter Winters (2080's Medium emissions)					Threat	3	4	12	3	4	12	24	2	#M		
	Wetter Winters (2080's High emissions)					Threat	3	4	12	3	4	12	24	2	#M		
3	Wetter Winters (2050's Medium emissions)	Increased winter river flows, baseflows will be higher going in to the summer	More physical resource to abstract, potential winter storage	Water Resources	River abstractio ns	Opportunity	5	2	10	4	3	12	22	2	#L	This is an opportunity due to potential increased resource. Level 3 severity selected to reflect the positive impact. We would have to consider the regulatory licensing strategy as this may prevent use of additional resource if became available.	(Principal Hydrologist Impact of UKCP09 on Water Resource Plans -Initial Assessment by Mott Macdonald's 2009
	Wetter Winters (2050's High emissions)					Opportunity	5	2	10	4	3	12	22	2	#L		
	Wetter Winters (2080's Medium emissions)					Opportunity	5	2	10	4	3	12	22	2	#L		
	Wetter Winters (2080's High emissions)					Opportunity	5	2	10	4	3	12	22	2	#L		
4	Wetter Winters (2050's Medium emissions)	Increased winter raw reservoir levels	More physical resource, increased winter storage	Water Resources	Reservoirs	Opportunity	5	2	10	4	3	12	22	2	#M	This is an opportunity due to potential increased resource. Level 3 severity selected to reflect the positive impact.	Principal Hydrologist Impact of UKCP09 on Water Resource Plans -Initial Assessment by Mott Macdonald's 2009
	Wetter Winters (2050's High emissions)					Opportunity	5	2	10	4	3	12	22	2	#M		
	Wetter Winters (2080's Medium emissions)					Opportunity	5	2	10	4	3	12	22	2	#M		
	Wetter Winters (2080's High emissions)					Opportunity	5	2	10	4	3	12	22	2	#M		
5	Wetter Winters (2050's Medium emissions)	Increased risk of flooding due to silt movement caused by high river base flows	Silt blocking river intakes leading to increased outages and reduced abstraction capacity	Water Resources	River Abstractio ns	Threat	3	3	9	3	4	12	21	1	#L	High river base flow can cause movement of sediments within the river bed (and from overland flow) causing blockages at river inlets/abstractions. This can reduce the deployable output of the source and increased outages	Principal Hydrologist
	Wetter Winters (2050's High emissions)					Threat	3	3	9	3	4	12	21	1	#L		
	Wetter Winters (2080's Medium emissions)					Threat	3	3	9	3	4	12	21	1	#L		
	Wetter Winters (2080's High emissions)					Threat	3	3	9	3	4	12	21	1	#L		

																on site.	
6	Wetter Winters (2050's Medium emissions)	Increased risk of flooding of river intakes and water treatment works due to high river levels	Flooding causes damage to equipment, power outages and site safety issues, all of which can lead to increased outages and reduced abstraction capacity	Water Resources	River Abstractions	Threat	3	2	6	2	3	6	12	1	#L	High river flows can lead to flooding of river inlets and water treatment works. However, this would impact few of our sites as most equipment is located away from the river intakes. Our AMP5 Business Resilience Programme should address any potential issues at sites at risk of river flooding	Principal Hydrologist
	Wetter Winters (2050's High emissions)					Threat	3	2	6	2	3	6	12	1	#L		
	Wetter Winters (2080's Medium emissions)					Threat	3	2	6	2	3	6	12	1			
	Wetter Winters (2080's High emissions)					Threat	3	2	6	2	3	6	12	1	#L		
7	Wetter Winters (2050's Medium emissions)	Increased winter raw reservoir levels	Greater utilisation of river compensation releases from raw water impounding reservoirs for Hydro-Electric Power generation	Water Resources	Reservoirs	Opportunity	5	2	10	1	3	3	13	1	#M	Investment would be required to increase capacity of current HEP schemes and / or create schemes at our other raw water reservoirs.	Renewable Energy Manager
	Wetter Winters (2050's High emissions)					Opportunity	5	2	10	1	3	3	13	1	#M		
	Wetter Winters (2080's Medium emissions)					Opportunity	5	2	10	1	3	3	13	1	#M		
	Wetter Winters (2080's High emissions)					Opportunity	5	2	10	1	3	3	13	1	#M		
Climate Driver: Increased Winter Mean temperature																	
8	Warmer winters (2050's Medium emissions)	Increased evapotranspiration	Lower rate of recharge	Water Resources	Borehole Pumping Stations	Neutral	1	1	1	4	1	4	5	2	#L	Minor increase in evapotranspiration is anticipated, based on Entec projections.	Senior Hydrogeologist Impact of Climate Change on Deployable Output, report by Entec UK Limited 2009
	Warmer winters (2050's High emissions)					Neutral	1	1	1	4	1	4	5	2	#L		
	Warmer winters (2080's Medium emissions)					Neutral	1	1	1	4	1	4	5	2	#L		
	Warmer winters (2080's High emissions)					Neutral	1	1	1	4	1	4	5	2	#L		
9	Warmer winters (2050's Medium emissions)	Increased evapotranspiration	Lower winter river flows leading to lower summer base flows	Water Resources	River abstractions	Threat	4	3	12	4	1	4	16	2	#L	Consequences may be less severe due to higher winter base levels, assuming we have higher winter precipitation (see 3).	Principal Hydrologist Impact of UKCP09 on Water Resource Plans -Initial Assessment by Mott Macdonald's 2009
	Warmer winters (2050's High emissions)					Threat	4	3	12	4	1	4	16	2	#L		
	Warmer winters (2080's Medium emissions)					Threat	3	3	9	4	2	8	17	2	#L		
	Warmer winters (2080's High emissions)					Threat	3	3	9	4	2	8	17	2	#L		
10	Warmer winters (2050's Medium emissions)	Increased evapotranspiration	Lower reservoir levels	Water Resources	Reservoirs	Threat	5	2	10	4	2	8	18	2	#L	Consequences may be less severe assuming higher winter precipitation (see 3).	Principal Hydrologist Impact of UKCP09 on Water Resource Plans -Initial Assessment by Mott Macdonald's 2009
	Warmer winters (2050's High emissions)					Threat	5	2	10	4	2	8	18	2	#L		
	Warmer winters (2080's Medium emissions)					Threat	5	3	15	4	2	8	23	2	#L		
	Warmer winters (2080's High emissions)					Threat	5	3	15	4	2	8	23	2	#L		
11	Warmer winters (2050's Medium emissions)	Lower number of frost events	Reduced leakage breakout	Water Network	Distribution pipes	Opportunity	4	3	12	5	2	10	22	1	#M	Relationships between temperature, leakage and bursts not well established with STW data. Past studies have shown 4 degrees Celsius is the trigger level for leakage activity in	Leakage Strategy Manager
	Warmer winters (2050's High emissions)					Opportunity	4	3	12	5	2	10	22	1	#M		
	Warmer winters (2080's Medium emissions)					Opportunity	4	3	12	5	2	10	22	1	#M		
	Warmer winters (2080's High emissions)					Opportunity	4	3	12	5	2	10	22	1	#M		

																the winter, 3-4 consecutive frost days increases likelihood of bursts to occur. Impacts mainly metallic mains.	
12	Warmer winters (2050's Medium emissions)	Milder winters	Increase in household demand	Water Resources	All	Threat	3	3	9	5	1	5	14	1	#L	Warmer forecast for winter temp has little impact on demand. The demand profile over the winter generally stays relatively constant.	DCM team Data Manager Demand Analyst
	Warmer winters (2050's High emissions)					Threat	3	3	9	5	1	5	14	1	#L		
	Warmer winters (2080's Medium emissions)					Threat	3	3	9	5	1	5	14	1	#L		
	Warmer winters (2080's High emissions)					Threat	3	3	9	5	1	5	14	1	#L		
13	Warmer winters (2050's Medium emissions)	Higher demand	More areas at risk of failing pressure reference level	Water Network	Pressure boosters, service reservoirs, dist mains	Threat	3	2	6	2	3	6	12	1	#L	Potentially higher average demand places stress on maintaining pressure levels currently. All scenarios will exacerbate this.	Chris Bridge Distribution Strategy Analyst DG2 Analyst
	Warmer winters (2050's High emissions)					Threat	3	2	6	2	3	6	12	1	#L		
	Warmer winters (2080's Medium emissions)					Threat	3	2	6	2	3	6	12	1	#L		
	Warmer winters (2080's High emissions)					Threat	3	2	6	2	3	6	12	1	#L		
14	Warmer winters (2050's Medium emissions)	Increased bacteriological growth in the distribution system (including reduced winter die off)	Risk of bacteriological failure - controlled by distribution chlorination and/or treatment works organics removal.	Water Network	Chlorine boosters, service reservoirs, dist mains,	Threat	4	4	16	2	2	4	20	1	#M	This is likely to isolated failures affecting small sections of the distribution system.	Distribution Strategy Analyst
	Warmer winters (2050's High emissions)					Threat	4	4	16	2	2	4	20	1	#M		
	Warmer winters (2080's Medium emissions)					Threat	4	4	16	2	2	4	20	1	#M		
	Warmer winters (2080's High emissions)					Threat	4	4	16	2	2	4	20	1	#M		
Climate Driver: Increased Summer mean temperature																	
15	Warmer summers (2050's Medium emissions)	Increased Evaporation	Drying of wetland areas and small watercourses, leading to possible licence restrictions	Water Resources	Borehole Pumping Stations	Threat	3	4	12	4	3	12	24	2	#M	Abstraction may need to be reduced to protect sensitive wetlands in catchments through regulatory pressure.	Senior Hydrogeologist Impact of Climate Change on Deployable Output, report by Entec UK Limited 2009
	Warmer summers (2050's High emissions)					Threat	3	4	12	4	3	12	24	2	#M		
	Warmer summers (2080's Medium emissions)					Threat	3	4	12	4	3	12	24	2	#M		
	Warmer summers (2080's High emissions)					Threat	3	4	12	4	3	12	24	2	#M		
16	Warmer summers (2050's Medium emissions)	Lower river flows	Abstraction restrictions, greater regulation	Water Resources	River abstractio ns	Threat	5	4	20	4	4	16	36	2	#H	Less water to abstract from rivers, further reductions possible through regulatory pressures and practices.	Principal Hydrologist Impact of UKCP09 on Water Resource Plans -Initial Assessment by Mott Macdonald's 2009
	Warmer summers (2050's High emissions)					Threat	5	4	20	4	4	16	36	2	#H		
	Warmer summers (2080's Medium emissions)					Threat	5	4	20	4	5	20	40	2	#H		
	Warmer summers (2080's High emissions)					Threat	5	4	20	4	5	20	40	2	#H		
17	Warmer summers (2050's Medium emissions)	Lower river flows	Increased compensation releases. Releases from compensation boreholes are linked to the levels of the nearby river/stream. Lower levels would trigger releases more frequently and for longer periods.	Water Resources	Borehole/ Reservoirs	Threat	5	4	20	2	4	8	28	2	#M	Increased compensation releases required due to lower river flows, this will also reduce deployable output and the company will be subject to greater regulation.	Principal Hydrologist Impact of UKCP09 on Water Resource Plans -Initial Assessment by Mott Macdonald's 2009
	Warmer summers (2050's High emissions)					Threat	5	4	20	2	4	8	28	2	#M		
	Warmer summers (2080's Medium emissions)					Threat	5	4	20	2	4	8	28	2	#M		
	Warmer summers (2080's High emissions)					Threat	5	4	20	2	4	8	28	2	#M		
18	Warmer summers (2050's Medium emissions)	Raw reservoir levels	Low reservoir levels, crossing trigger levels earlier and	Water Resources	Reservoirs	Threat	5	4	20	4	4	16	36	2	#H	Impacts on company strategy, water availability and levels of	Principal Hydrologist Impact of UKCP09 on
	Warmer summers (2050's High emissions)					Threat	5	4	20	4	4	16	36	2	#H		

	Warmer summers (2080's Medium emissions)		more frequently			Threat	5	4	20	4	5	20	40	2	#H	service.	Water Resource Plans -Initial Assessment by Mott Macdonald's 2009
	Warmer summers (2080's High emissions)					Threat	5	4	20	4	5	20	40	2	#H		
19	Warmer summers (2050's Medium emissions)	Lower river levels	Increased compensation releases required from raw water reservoirs. Certain reservoirs have licence conditions requiring releases (or increased releases) to be made once the river reaches a particular level.	Water Resources	Reservoirs	Threat	5	4	20	2	4	8	28	2	#M	Increased compensation releases required due to lower river flows, this will also reduce water available for supply and the company will be subject to greater regulation.	Principal Hydrologist Impact of UKCP09 on Water Resource Plans -Initial Assessment by Mott Macdonald's 2009
	Warmer summers (2050's High emissions)					Threat	5	4	20	2	4	8	28	2	#M		
	Warmer summers (2080's Medium emissions)					Threat	5	4	20	2	4	8	28	2	#M		
	Warmer summers (2080's High emissions)					Threat	5	4	20	2	4	8	28	2	#M		
20	Warmer summers (2050's Medium emissions)	Pressure on ecological flow indicator	Further reductions in river abstraction licences	Water Resources	River abstractions	Threat	5	5	25	4	5	20	45	2	#H	This relates to the Water Framework Directive. Consequences are already being felt of warmer summers, projected increases in summer temperatures will further deteriorate the situation.	Water Resource Planner Climate-change Impacts on River Flows in Britain: The UKCIP02 Scenarios by Arnell 2004 The effects of climate change due to global warming on river flows by Arnell 1996
	Warmer summers (2050's High emissions)					Threat	5	5	25	4	5	20	45	2	#H		
	Warmer summers (2080's Medium emissions)					Threat	5	5	25	4	5	20	45	2	#H		
	Warmer summers (2080's High emissions)					Threat	5	5	25	4	5	20	45	2	#H		
21	Warmer summers (2050's Medium emissions)	Pressure on ecological flow indicator	Further reductions in boreholes abstraction licences	Water Resources	Boreholes	Threat	5	5	25	4	5	20	45	2	#H	Groundwater affects river flows, projected increases in summer temperatures will further deteriorate the situation.	Water Resource Planner Climate-change Impacts on River Flows in Britain: The UKCIP02 Scenarios by Arnell 2004 The effects of climate change due to global warming on river flows by Arnell 1996
	Warmer summers (2050's High emissions)					Threat	5	5	25	4	5	20	45	2	#H		
	Warmer summers (2080's Medium emissions)					Threat	5	5	25	4	5	20	45	2	#H		
	Warmer summers (2080's High emissions)					Threat	5	5	25	4	5	20	45	2	#H		
22	Warmer summers (2050's Medium emissions)	High demand	Breaking annual / 5 year licences	Water Resources	Boreholes	Threat	2	3	6	2	3	6	12	2	#L	Will need to find alternative sources if frequency of licence breaches increases.	Water Resource Planner Climate-change Impacts on River Flows in Britain: The UKCIP02 Scenarios by Arnell 2004 The effects of climate change due to global warming on river flows by Arnell 1996
	Warmer summers (2050's High emissions)					Threat	2	3	6	2	3	6	12	2	#L		
	Warmer summers (2080's Medium emissions)					Threat	2	3	6	2	3	6	12	2	#L		
	Warmer summers (2080's High emissions)					Threat	2	3	6	2	3	6	12	2	#L		
23	Warmer Summers (2050's medium emissions)	Higher evaporation	Lower river levels leads to less dilution of pollutants. River quality will deteriorate	Water treatment	River abstractions	Threat	2	4	8	3	4	12	20	2	#M	Impact on company strategy due to costs incurred as a result of changing treatment processes and developing new treatment works.	Water Resource Planner Climate-change Impacts on River Flows in Britain: The UKCIP02 Scenarios by Arnell 2004 The effects of climate change
	Warmer Summers (2050's high emissions)					Threat	2	4	8	3	4	12	20	2	#M		
	Warmer Summers (2080's medium emissions)					Threat	2	4	8	3	4	12	20	2	#M		
	Warmer Summers					Threat	2	4	8	3	4	12	20	2	#M		

	(2080's high emissions)																due to global warming on river flows by Arnell 1996
24	Warmer Summers (2050's medium emissions)	Increase in Soil Moisture Deficit (SMD)	Increased leakage breakout	Water Network	Distribution pipes	Threat	4	3	12	4	3	12	24	2	#L	Relationships between temperature, leakage and bursts not well established with STW, impacts mostly on non-metallic mains.	Leakage Strategy Manager
	Warmer Summers (2050's high emissions)					Threat	4	3	12	4	3	12	24	2	#L		
	Warmer Summers (2080's medium emissions)					Threat	4	3	12	4	3	12	24	2	#L		
	Warmer Summers (2080's high emissions)					Threat	4	3	12	4	3	12	24	2	#L		
25	Warmer Summers (2050's medium emissions)	High demand	More areas at risk of failing pressure reference level	Water Network	Pressure boosters, service reservoirs, dist mains	Threat	5	4	20	2	3	6	26	1	#L	Under current conditions higher average demand places stress on maintaining pressure levels. This will also increase risk to supply. All scenarios will exacerbate this.	Distribution Strategy Analyst/DG2 Analyst
	Warmer Summers (2050's high emissions)					Threat	5	4	20	2	3	6	26	1	#L		
	Warmer Summers (2080's medium emissions)					Threat	5	4	20	2	3	6	26	1	#L		
	Warmer Summers (2080's high emissions)					Threat	5	4	20	2	3	6	26	1	#L		
26	Warmer Summers (2050's medium emissions)	Increase in algal blooms in reservoirs	Affects water quality, reducing the volume that can be abstracted and treated at any one time and reducing the volumes that can be output into supply.	Water Resources	Raw water reservoirs, service reservoirs, Water treatment works	Threat	4	4	16	3	3	9	25	1	#M	Increased algal blooms lead to decreased treatment capacity, increased outages at treatment works. This will impact on company strategy as supply availability and deployable output will be reduced as a result. It can also cause taste and odour problems if not treated correctly.	Principal Hydrologist
	Warmer Summers (2050's high emissions)					Threat	4	4	16	3	3	9	25	1	#M		
	Warmer Summers (2080's medium emissions)					Threat	4	4	16	3	3	9	25	1	#M		
	Warmer Summers (2080's high emissions)					Threat	4	4	16	3	3	9	25	1	#M		
27	Warmer Summers (2050's medium emissions)	Increase in algal blooms in reservoirs	Affects water quality, impacting the operation of the treatment works (e.g. requires more back washing of filters) and the types of treatment process which need to be used	Water Resources	Water treatment works	Threat	4	4	16	3	3	9	25	1	#M	Increased algal blooms lead to decreased treatment capacity, increased outages at treatment works. This will impact on company strategy as supply availability and deployable output will be reduced as a result. It can also cause taste and odour problems if not treated correctly.	Principal Hydrologist
	Warmer Summers (2050's high emissions)					Threat	4	4	16	3	3	9	25	1	#M		
	Warmer Summers (2080's medium emissions)					Threat	4	4	16	3	3	9	25	1	#M		
	Warmer Summers (2080's high emissions)					Threat	4	4	16	3	3	9	25	1	#M		
28	Warmer Summers (2050's medium emissions)	Increased demand	Pipe bursts due to over pumping	Water Network	Distribution pipes	Threat	3	2	6	2	2	4	10	1	#L	This is likely to cause localised problems in the distribution system due to increased pressures from extra pumping in the network.	Leakage Strategy Manager
	Warmer Summers (2050's high emissions)					Threat	3	2	6	2	2	4	10	1	#L		
	Warmer Summers (2080's medium emissions)					Threat	3	2	6	2	2	4	10	1	#L		
	Warmer Summers (2080's high emissions)					Threat	3	2	6	2	2	4	10	1	#L		
29	Warmer Summers	Increased Soil	Causing	Water	Distributio	Threat	4	4	16	2	3	6	22	1	#L	This is likely to	Leakage

	(2050's medium emissions)	Moisture Deficit	ground movement which will lead to increased burst events	Network	n pipes											cause localised problems in the distribution system due to bursts causing DG2 (pressure) and DG3 (loss of supply) issues. SMD driven failures are generally dramatic - complete failure of the main.	Strategy Manager
	Warmer Summers (2050's high emissions)					Threat	4	4	16	2	3	6	22	1	#L		
	Warmer Summers (2080's medium emissions)					Threat	4	4	16	2	3	6	22	1	#L		
	Warmer Summers (2080's high emissions)					Threat	4	4	16	2	3	6	22	1	#L		
30	Warmer Summers (2050's medium emissions)	Increasing Soil Moisture Deficit (SMD)	Increased domestic demand	Water Resources	All	Threat	5	5	25	5	3	15	40	2	#M	Domestic Consumption Monitor (DCM) team data analysis has identified a relationship between SMD and domestic demand (based on 2003 summer, when SMD reaches 60mm, we see an increase in domestic demand). Localised supply issue (e.g. reduced pressures).	DCM team Data Manager/ Demand Analyst
	Warmer Summers (2050's high emissions)					Threat	5	5	25	5	3	15	40	2	#M		
	Warmer Summers (2080's medium emissions)					Threat	5	5	25	5	3	15	40	2	#M		
	Warmer Summers (2080's high emissions)					Threat	5	5	25	5	3	15	40	2	#M		
31	Warmer winters (2050's Medium emissions)	Increased bacteriological growth in the distribution system (including reduced winter die off)	Risk of bacteriological failure - controlled by distribution chlorination and/or treatment works organics removal.	Water Network	Chlorine boosters, service reservoirs, dist mains,	Threat	4	4	16	2	2	4	20	1	#M	This is likely to isolated failures affecting small sections of the distribution system.	Distribution Strategy Analyst
	Warmer winters (2050's High emissions)					Threat	4	4	16	2	2	4	20	1	#M		
	Warmer winters (2080's Medium emissions)					Threat	4	4	16	2	2	4	20	1	#M		
	Warmer winters (2080's High emissions)					Threat	4	4	16	2	2	4	20	1	#M		
Climate Driver: Decreasing Summer precipitation																	
32	Drier Summers (2050's medium emissions)	Lower river flows due to groundwater depletion	Licence restrictions	Water Resources	Borehole Pumping Stations	Threat	3	4	12	3	3	9	21	2	#M	Abstraction may need to be reduced to protect sensitive rivers and streams due to regulatory pressure.	Senior Hydrogeologist Impact of Climate Change on Deployable Output, report by Entec UK Limited 2009
	Drier Summers (2050's high emissions)					Threat	3	4	12	3	3	9	21	2	#M		
	Drier Summers (2080's medium emissions)					Threat	3	4	12	3	3	9	21	2	#M		
	Drier Summers (2080's high emissions)					Threat	3	4	12	3	3	9	21	2	#M		
33	Drier Summers (2050's medium emissions)	Lower river flows	Abstraction restrictions, greater regulation	Water Resources	River abstractions	Threat	5	4	20	4	5	20	40	2	#H	Less water to abstract from rivers, further reductions possible through regulatory pressures and practices.	Principal Hydrologist Impact of UKCP09 on Water Resource Plans -Initial Assessment by Mott Macdonald's 2009
	Drier Summers (2050's high emissions)					Threat	5	4	20	4	5	20	40	2	#H		
	Drier Summers (2080's medium emissions)					Threat	5	4	20	4	5	20	40	2	#H		
	Drier Summers (2080's high emissions)					Threat	5	4	20	4	5	20	40	2	#H		
34	Drier Summers (2050's medium emissions)	Lower river flows	Increased compensation. Releases from compensation boreholes are linked to the levels of the nearby river/stream. Lower levels would trigger releases more frequently and	Water Resources	Borehole	Threat	5	4	20	4	4	16	36	2	#M	Increased compensation releases required due to lower river flows, this will also reduce deployable output and the company will be subject to greater regulation.	Principal Hydrologist Impact of UKCP09 on Water Resource Plans -Initial Assessment by Mott Macdonald's 2009
	Drier Summers (2050's high emissions)					Threat	5	4	20	4	4	16	36	2	#M		
	Drier Summers (2080's medium emissions)					Threat	5	4	20	4	5	20	40	2	#M		
	Drier Summers (2080's high emissions)					Threat	5	4	20	4	5	20	40	2	#M		

			for longer periods														
35	Drier Summers (2050's medium emissions)	Raw reservoir levels	Low reservoir levels, crossing trigger levels earlier and more frequently	Water Resources	Reservoirs	Threat	5	4	20	4	4	16	36	2	#H	Impacts on company strategy, water availability and levels of service.	Principal Hydrologist Impact of UKCP09 on Water Resource Plans -Initial Assessment by Mott Macdonald's 2009
	Drier Summers (2050's high emissions)					Threat	5	4	20	4	4	16	36	2	#H		
	Drier Summers (2080's medium emissions)					Threat	5	4	20	4	4	16	36	2	#H		
	Drier Summers (2080's high emissions)					Threat	5	4	20	4	4	16	36	2	#H		
36	Drier Summers (2050's medium emissions)	Lower river levels	Increased compensation releases required from raw water reservoirs. Certain reservoirs have licence conditions requiring releases (or increased releases) to be made once the river reaches a particular level.	Water Resources	Reservoirs	Threat	5	4	20	2	4	8	28	2	#M	Increased compensation releases required due to lower river flows, this will also reduce water available for supply and the company will be subject to greater regulation.	Principal Hydrologist Impact of UKCP09 on Water Resource Plans -Initial Assessment by Mott Macdonald's 2009
	Drier Summers (2050's high emissions)					Threat	5	4	20	2	4	8	28	2	#M		
	Drier Summers (2080's medium emissions)					Threat	5	4	20	2	4	8	28	2	#M		
	Drier Summers (2080's high emissions)					Threat	5	4	20	2	4	8	28	2	#M		
37	Drier Summers (2050's medium emissions)	Pressure on ecological flow indicator	Further reductions in abstraction licences	Water Resources	River abstractions	Threat	5	5	25	4	5	20	45	2	#H	This relates to the Water Framework Directive. Consequences are already being felt of drier summers; projected decrease in summer precipitation will further deteriorate the situation.	Water Resource Planner Climate-change Impacts on River Flows in Britain: The UKCIP02 Scenarios by Arnell 2004 The effects of climate change due to global warming on river flows by Arnell 1996
	Drier Summers (2050's high emissions)					Threat	5	5	25	4	5	20	45	2	#H		
	Drier Summers (2080's medium emissions)					Threat	5	5	25	4	5	20	45	2	#H		
	Drier Summers (2080's high emissions)					Threat	5	5	25	4	5	20	45	2	#H		
38	Drier Summers (2050's medium emissions)	Pressure on ecological flow indicator	Further reductions in abstraction licences	Water Resources	Boreholes	Threat	5	5	25	4	3	12	37	2	#H	Groundwater affects river flows, projected increases in summer temperatures will further deteriorate the situation.	Water Resource Planner Climate-change Impacts on River Flows in Britain: The UKCIP02 Scenarios by Arnell 2004 The effects of climate change due to global warming on river flows by Arnell 1996
	Drier Summers (2050's high emissions)					Threat	5	5	25	4	3	12	37	2	#H		
	Drier Summers (2080's medium emissions)					Threat	5	5	25	4	3	12	37	2	#H		
	Drier Summers (2080's high emissions)					Threat	5	5	25	4	3	12	37	2	#H		
39	Drier Summers (2050's medium emissions)	Pressure on ecological flow indicator	Lower river levels leads to less dilution of pollutants. River quality will deteriorate	Water treatment	River abstractions	Threat	2	4	8	3	4	12	20	2	#M	Impact on company strategy due to costs incurred as a result of changing treatment processes and developing new treatment works.	Water Resource Planner Climate-change Impacts on River Flows in Britain: The UKCIP02 Scenarios by Arnell 2004 The effects of climate change due to global warming on river flows by Arnell 1996
	Drier Summers (2050's high emissions)					Threat	2	4	8	3	4	12	20	2	#M		
	Drier Summers (2080's medium emissions)					Threat	2	4	8	3	4	12	20	2	#M		
	Drier Summers (2080's high emissions)					Threat	2	4	8	3	4	12	20	2	#M		
40	Drier Summers (2050's medium emissions)	Reduced resource availability	Marginal value of water increases	Water Resources	River abstractions/	Threat	5	4	20	5	4	20	40	1	#M	Impact on company strategy due to change in	Leakage Strategy Manager
	Drier Summers (2050's					Threat	5	4	20	5	4	20	40	1	#M		

	high emissions)		significantly, re-deployment of staff resources to water stressed areas		Reservoirs / Boreholes											SELL. Impact on Water Resources Planning requires investigation.	
	Drier Summers (2080's medium emissions)					Threat	5	4	20	5	4	20	40	1	#M		
	Drier Summers (2080's high emissions)					Threat	5	4	20	5	4	20	40	1	#M		
41	Drier Summers (2050's medium emissions)	Increased demand	Pipe bursts due to over pumping	Water Network	Distribution pipes	Threat	3	2	6	2	2	4	10	1	#L	This is likely to cause localised problems in the distribution system due to increased pressures from extra pumping in the network.	Leakage Strategy Manager
	Drier Summers (2050's high emissions)					Threat	3	2	6	2	2	4	10	1	#L		
	Drier Summers (2080's medium emissions)					Threat	3	2	6	2	2	4	10	1	#L		
	Drier Summers (2080's high emissions)					Threat	3	2	6	2	2	4	10	1	#L		
42	Drier Summers (2050's medium emissions)	Increased Soil Moisture Deficit	Causing ground movement which will lead to increased burst events	Water Network	Distribution pipes	Threat	4	4	16	2	3	6	22	2	#L	This is likely to cause localised problems in the distribution system due to bursts causing DG2 (pressure) and DG3 (loss of supply) issues. SMD driven failures are generally dramatic - complete failure of the main.	Leakage Strategy Manager UKWIR (2007) Managing Seasonal Variations in Leakage
	Drier Summers (2050's high emissions)					Threat	4	4	16	2	3	6	22	2	#L		
	Drier Summers (2080's medium emissions)					Threat	4	4	16	2	3	6	22	2	#L		
	Drier Summers (2080's high emissions)					Threat	4	4	16	2	3	6	22	2	#L		
43	Drier summers (2050's Medium emissions)	Increasing Soil Moisture Deficit (SMD)	Increased domestic demand	Water Resources	All	Threat	5	5	25	5	3	15	40	2	#M	Domestic Consumption Monitor (DCM) team data analysis has identified a relationship between SMD and domestic demand (based on 2003 summer, when SMD reaches 60mm, we see an increase in domestic demand). Localised supply issue (e.g. reduced pressures).	DCM team Data Manager Demand Analyst
	Drier summers (2050's High emissions)					Threat	5	5	25	5	3	15	40	2	#M		
	Drier summers (2080's Medium emissions)					Threat	5	5	25	5	3	15	40	2	#M		
	Drier summers (2080's High emissions)					Threat	5	5	25	5	3	15	40	2	#M		
Climate Driver: Summer maximum daily temperature																	
44	Extreme higher temperatures (2050's, medium emissions)	High demand	Breaking river abstraction daily licence	Water Resources	River abstractions	Threat	3	3	9	2	3	6	15	2	#L	Risk to individual licences, cost to company is fines for licence and bad publicity. This will largely be a localised issue.	Water Resource Planner Climate-change Impacts on River Flows in Britain: The UKCIP02 Scenarios by Arnell 2004 The effects of climate change due to global warming on river flows by Arnell 1996
	Extreme higher temperatures (2050's, high emissions)					Threat	3	3	9	2	3	6	15	2	#L		
	Extreme higher temperatures (2080's, medium emissions)					Threat	3	3	9	2	3	6	15	2	#L		
	Extreme higher temperatures (2080's, high emissions)					Threat	3	3	9	2	3	6	15	2	#L		
45	Extreme higher temperatures (2050's, medium emissions)	High demand	Breaking groundwater daily licence	Water Resources	Borehole abstractions	Threat	3	3	9	2	3	6	15	2	#L	Risk to individual licences, cost to company is fines for licence and bad publicity. This will largely be a localised issue.	Water Resource Planner Climate-change Impacts on River Flows in Britain: The UKCIP02 Scenarios by Arnell 2004 The effects of climate change due to global warming on river
	Extreme higher temperatures (2050's, high emissions)					Threat	3	3	9	2	3	6	15	2	#L		
	Extreme higher temperatures (2080's, medium emissions)					Threat	3	3	9	2	3	6	15	2	#L		
	Extreme higher temperatures (2080's,					Threat	3	3	9	2	3	6	15	2	#L		

	high emissions)																flows by Arnell 1996
46	Extreme higher temperatures (2050's, medium emissions)	Reduced resource availability	Re-deployment of staff resources	Water Resources	River abstractions/ Reservoirs / Boreholes	Threat	5	3	15	3	3	9	24	1	#L	Impact on company strategy. Requires improved dry weather event response planning and re-deployment of staff resources to water stressed areas.	Leakage Strategy Manager
	Extreme higher temperatures (2050's, high emissions)					Threat	5	3	15	3	3	9	24	1	#L		
	Extreme higher temperatures (2080's, medium emissions)					Threat	5	3	15	3	3	9	24	1	#L		
	Extreme higher temperatures (2080's, high emissions)					Threat	5	3	15	3	3	9	24	1	#L		
47	Extreme higher temperatures (2050's, medium emissions)	High demand	More areas at risk of failing pressure reference level	Water Network	Pressure boosters, service reservoirs, dist mains	Threat	5	4	20	2	3	6	26	1	#L	Peak demand places stress on maintaining pressure levels currently. All scenarios will exacerbate this.	Distribution Strategy Analyst / DG2 Analyst
	Extreme higher temperatures (2050's, high emissions)					Threat	5	4	20	2	3	6	26	1	#L		
	Extreme higher temperatures (2080's, medium emissions)					Threat	5	4	20	2	3	6	26	1	#L		
	Extreme higher temperatures (2080's, high emissions)					Threat	5	4	20	2	3	6	26	1	#L		
48	Extreme higher temperatures (2050's, medium emissions)	Increased demand	Pipe bursts due to over pumping	Water Network	Distribution pipes	Threat	3	2	6	2	2	4	10	1	#L	This is likely to cause localised problems in the distribution system due to increased pressures from extra pumping in the network.	Leakage Strategy Manager
	Extreme higher temperatures (2050's, high emissions)					Threat	3	2	6	2	2	4	10	1	#L		
	Extreme higher temperatures (2080's, medium emissions)					Threat	3	2	6	2	2	4	10	1	#L		
	Extreme higher temperatures (2080's, high emissions)					Threat	3	2	6	2	2	4	10	1	#L		
49	Warmer winters (2050's Medium emissions)	Increased bacteriological growth in the distribution system (including reduced winter die off)	Risk of bacteriological failure - controlled by distribution chlorination and/or treatment works organics removal.	Water Network	Chlorine boosters, service reservoirs, dist mains,	Threat	4	4	16	2	2	4	20	1	#M	This is likely to isolated failures affecting small sections of the distribution system.	Distribution Strategy Analyst
	Warmer winters (2050's High emissions)					Threat	4	4	16	2	2	4	20	1	#M		
	Warmer winters (2080's Medium emissions)					Threat	4	4	16	2	2	4	20	1	#M		
	Warmer winters (2080's High emissions)					Threat	4	4	16	2	2	4	20	1	#M		
Climate Driver: Increased winter minimum daily temp																	
50	Warmer winters (2050's Medium emissions)	Lower number of frost events	Reduced burst events	Water Network	Distribution pipes	Opportunity	4	3	12	5	2	10	22	2	#M	Relationships between temperatures, leakage, bursts not well established with STW data. Requires further investigation to understand level of opportunity.	Leakage Strategy Manager
	Warmer winters (2050's High emissions)					Opportunity	4	3	12	5	2	10	22	2	#M		
	Warmer winters (2080's Medium emissions)					Opportunity	4	3	12	5	2	10	22	2	#M		
	Warmer winters (2080's High emissions)					Opportunity	4	3	12	5	2	10	22	2	#M		
51	Warmer winters (2050's Medium emissions)	Higher demand	More areas at risk of failing pressure reference level	Water Network	Pressure boosters, service reservoirs, dist mains	Threat	3	2	6	2	3	6	12	1	#L	Potential higher average demand places stress on maintaining pressure levels currently. All scenarios will exacerbate this.	Distribution Strategy Analyst / DG2 Analyst
	Warmer winters (2050's High emissions)					Threat	3	2	6	2	3	6	12	1	#L		
	Warmer winters (2080's Medium emissions)					Threat	3	2	6	2	3	6	12	1	#L		
	Warmer winters (2080's High emissions)					Threat	3	2	6	2	3	6	12	1	#L		
52	Warmer winters (2050's Medium emissions)	Increased bacteriological growth in the distribution system (including	Risk of bacteriological failure - controlled by	Water Network	Chlorine boosters, service reservoirs,	Threat	4	4	16	2	2	4	20	1	#M	This is likely to isolated failures affecting small sections of the	Distribution Strategy Analyst
	Warmer winters (2050's High emissions)					Threat	4	4	16	2	2	4	20	1	#M		

	Warmer winters (2080's Medium emissions)	reduced winter die off)	distribution chlorination and/or treatment works organics removal.		dist mains,	Threat	4	4	16	2	2	4	20	1	#M	distribution system.	
	Warmer winters (2080's High emissions)					Threat	4	4	16	2	2	4	20	1	#M		

A3.2 Waste Water Services Directorate

Ref #	Climate Effect	Climate Impact	Consequence	Asset level 2	Asset level 3	T/O/N	Proximity vs. likelihood			Impact			Overall Risk Rating	Pedigree	Level of Confidence	STW Expert comments	STW Rationale & Assumptions &Data/Evidence Source
							Proximity	Likelihood	Total	Properties	Severity	Total					
Climate Driver: Low Summer Precipitation																	
1	Lower precipitation, infiltration & inflow plus water conservation,	Lower river flows, increased seasonal variability and reduced water quality.	Lower average and peak 'carry' flows, resulting in greater sewer deposits and more frequent blockages, causing local sewer flooding & pollutions.	Waste Water Network	Sewer Network and Pumping Stations	Threat	1	4	4	1	3	3	7	3	#H	Our liability for sewer blockages and their consequences will increase when private sewers and lateral drains are transferred to us. We have experienced that blockages increase after period of dry periods.	UKCP09 is indicating lower dryer periods resulting in increased siltation and deposition of solid. Sewerage Strategy team.
2	Lower precipitation, infiltration & inflow plus water conservation,	Lower river flows, increased seasonal variability and reduced water quality.	Leading to the tightening of discharge consents, increasing the risk of a consent failure/pollution incident	Waste Water treatment	Waste Water Treatment	Threat	1	2	2	2	2	4	6	1	#L	We are working to understand how Sewage Treatment works can be impacted by lower consents and lower quality sewer flow. Our current data limited however as more data is available, we will make further assessments and risk mitigation plans.	Using UKCP09, we have identified low precipitation which could increase sewerage concentration to sewage treatment works, which could affect sewage treatment processes in treating effluent to meet consent levels. Waste Water Strategy.
3	Lower precipitation, infiltration & inflow plus water conservation,	Reduction in water quality.	Odour on Sewer Networks	Waste Water Network	Waste Water Treatment and Network	Threat	1	3	3	1	2	2	5	0	#L	Rise in odour complaints can be a concern but is dependent on wind direction and public tolerance to odour.	Lower precipitation will lead to longer retention times in wet wells and rising mains causing odour problems. Sewage Treatment strategy Manager.
4	Lower precipitation, infiltration & inflow plus water conservation,	Lower river flows, increased seasonal variability and reduced water quality.	Lower quality water could flow through CSOs to river.	Waste Water Network	CSOs and overflows	Threat	1	3	3	3	3	9	12	3	#M		CSO discharge consents consider dilution ratios in receiving water course. Sewerage Strategy team.
Climate Driver: High Winter Precipitation																	

5	Higher winter precipitation intensities	Higher precipitation intensities lead to runoff exceeding combined sewer capacity and sewerage tanks.	Causing surface flooding and reducing receiving water quality.	Waste Water Network	Sewer networks, incl./trunk sewers	Threat	2	4	8	3	4	12	20	3	#H	There are limitations in using the UKCP09 Weather Generator (WG) to assess potential CC impacts on sewer performance, as the WG is only able to disaggregate peak precipitation intensity from daily to hourly values, whereas sewer flooding events require sub-hourly (5 minute) precipitation values. The UKWIR CL10 approach has been used to translate WG outputs to generate CC uplift values which can be applied to precipitation intensity curves but this approach mimics the general UKCP09 outputs of wetter winters (i.e. positive CC uplift factors) and drier summers (negative CC uplift factors). Whilst this approach has been used for sewer flooding impact modelling further work needs to be undertaken to evaluate expected changes in seasonal storm intensity (wetter winters resulting in longer duration similar intensity storms with drier having lower precipitation volumes but increased intensity over a shorter time).	Sewer flooding CC impact assessments have been undertaken on 12 recently completed flood alleviation solutions to evaluate what remedial measures are required to mitigate the potential impacts of CC on design performance. We have used the UKWIR CL10 approach to derive precipitation intensity uplift values from location specific UKCP09 Weather Generator outputs using 1) medium emissions scenario, 2) summer and winter seasonality, 3) 50th percentile and 4) 2030 and 2050 time slices. We have not made any adjustments for changes in precipitation intensity/duration. These 12 solutions have been modelled to determine cost of restoring a 40 year flood protection including CC uplifts. We have used the UKCP09 Weather Generator outputs and the methodology suggested in the UKWIR CL10 report to determine CC uplift values for 12 recently completed flood alleviation solutions.
6	Higher winter precipitation intensities	Longer retention of water in storm tanks	increased septicity & odour and affecting process performance efficiency	Waste Water treatment	Waste Water Treatment	Threat	2	4	8	1	1	1	9	0	#L	We have conducted generic risk assessments on site to site basis and consider it low risk	Longer time to return sewage through the treatment works could lead to issues around meeting the consent at the outfall of the works (septicity) Sewage Treatment strategy Manager.

7	Higher winter precipitation intensities	Flooding of power plants/supply network.	Power Loss leading to service failure.	Waste Water Network	SPS	Threat	1	3	3	2	2	4	7	2	#M	We identified the Impact on works could be high if alternate power resources are not available. We will continue to monitor our energy consumption and understand how the risk is being mitigated by our energy suppliers.	Power supply can be interrupted due to flood effecting power lines/plants in the region. Sewage Treatment and Sludge Strategy team.
8	Higher winter precipitation intensities	Flooding of power plants/supply network.	Power Loss leading to service failure.	Waste Water treatment	Waste Water Treatment	Threat	1	3	3	2	2	4	7	2	#M	We identified the Impact on works could be high if alternate power resources are not available. We will continue to monitor our energy consumption and understand how the risk is being mitigated by our energy suppliers.	Power supply can be interrupted due to flood effecting power lines/plants in the region. Senior Asset Strategist & Sewage Treatment strategy Manager
9	Higher winter precipitation intensities	Intense precipitations leading to increase in sewerage flow	Overwhelming treatment processes	Waste Water treatment	Waste Water Treatment	Threat	2	2	4	2	2	4	8	2	#L	All of our Storm Tanks have been designed to meet consents levels to 68L/person. Most Sewage Treatment works have been designed to withstand 1 in 100 year flooding, therefore the risk impact is reduced.	This will not effect our larger works due to flow control penstocks, but on our smaller works where we treat all the flows this could lead to process issues on the site. Investment may be required to account for the additional flows. Sewage Treatment strategy Manager.
10	Higher winter precipitation intensities	Intense precipitations and greater river flows	Inundation of sewage pumping stations	Waste Water Network	Sewage pumping stations	Threat	2	4	8	3	2	6	14	2	*M	Potential impacts on sewage pumping station performance have not currently been assessed but the approach will be similar to that taken for sewer flooding impact evaluation (see comment 5).	Potential impacts on sewage pumping station performance have not currently been assessed but the approach will be similar to that taken for sewer flooding impact evaluation (see comment 5). Senior Sewerage Asset Strategist.
11	Higher winter precipitation intensities	Sludge overflow from land to river	Intense precipitation and flooding take sludge from land to river.	Sludge	Sludge to Land.	Threat	2	3	6	3	2	6	12	3	#M	Small sewage treatment works may be affected sludge cannot be removed if road access is unavailable.	Excess rain and flooding could carry sludge from land to river. Sludge to land route could be blocked. Sewage Treatment strategy Manager.

12	Higher winter precipitation intensities	Rise in temperature.	As sludge cannot be applied to the land when its wet, time for application of sludge to land route could be lengthened.	Sludge	Sludge to Land.	Threat	2	3	6	2	2	4	10	1	*M	Sludge cannot be applied on wet land due longer winter rain periods will disrupt sludge to land route, we will need to provide additional sludge storage facilities.	Unless alternative sludge disposal routes are defined, more storage for sludge will be required. Sewage Treatment strategy Manager.
13	Higher winter precipitation intensities	Intense precipitation leading to greater river flows	Inundation of Sewage Treatment works from river flooding	Waste Water Treatment	Waste Water Treatment	Threat	4	3	12	1	4	4	16	3	#M	The main consequence is damage to electrical equipment. We are improving resilience by lifting panels above flood levels.	Sewage Pumping stations are at risk if excess river water flows up the sewerage systems and damages electrical equipment. Sewage Treatment strategy Manager.
14	Higher winter precipitation intensities	Intense precipitation leading to greater river flows	Inundation of Sewage pumping stations from river flooding	Waste Water Network	Sewage pumping stations	Threat	3	3	9	1	2	2	11	3	#M	The main consequence is damage to electrical equipment. We are improving resilience by lifting panels above flood levels.	Most Sewage Treatment works have been designed to withstand 1 in 100 year flooding, therefore the risk impact is reduced. Sewage Treatment and Sludge Strategy team.
15	Higher winter precipitation intensities	increased periods of rain coverage.	reduced ability to access STW facilities preventing sludge transportation impacting sludge digestion process and sludge application.	Waste Water treatment	Sludge transportation & disposal. Tankered imports.	Threat	2	2	4	2	3	6	10	3	#M		Inaccessible sites may not have the capacity to store the sludge leading to PST's filling with sludge and leading to process problems. Waste workshop.
14	Higher summer storm intensity	Increased volumes of storm/river water	exceeding combined sewer capacity leading to local sewer flooding	Waste Water Network	Sewer networks, incl./trunk sewers	Threat	2	4	8	3	4	12	20	2	#L	See Comment 5	See Comment 5
15	Higher summer storm intensity	Increasing CSO spill frequency	lower receiving water quality	Waste Water Network	CSOs and overflows	Threat	2	4	8	2	3	6	14	2	#L	See Comment 5	See Comment 5
Climate Driver: High Temperatures																	
16	High Temperature	Rise in residential/commercial power demand	Rise in power outages leading to service failure	Waste Water treatment	Waste Water Treatment	Neutral	2	1	2	3	2	6	8	3	#M	Due to risk of reputation and public image, energy companies and govt will ensure power demand is met by installation of new power generation plants. Renewable Energy sources and CHP engines are used as alternate energy sources.	Excess demand due to air-conditioners could lead to excess power demand with power companies not able to cope with peak demands. Our assumption is that our power suppliers are aware of the risk and will mitigate the risk. Consultation with Senior Asset Strategist
17	High Temperature	Rise in peak consumption time periods	Shifting of Triad periods from Winter to Summer.	Waste Water treatment	Waste Water Treatment	Neutral	1	1	1	1	1	1	2	1	#M	Triads periods are applied in winter, however if summer power consumption increases, summer Triad periods could be applied. Dependent on increase in power generation capacity to cope with rise in consumption.	Sites may need to be operated to minimise the impact of the triad. Based on experience and discussions with Senior Asset Strategist (Sewage Treatment).

18	High Temperature	Rise in mean summer	Biological Treatment performance would improve leading improvement in effluent removal and meeting consent limits.	Waste Water treatment	Waste Water Treatment	Neutral	1	1	1	1	1	1	2	3	*M	Biological Processes performance would improve with rise in concentrated sewage inflow which is an opportunity however ASP processes may require excess oxygen, therefore overall treatment performance will remain unchanged.	Issues around oxygen transfer within ASP's/ Ditches Based on experience and discussions with Senior Asset Strategist (Sewage Treatment).
19	High Temperature	Rise in winter temperatures.	Biological Treatment performance would improve leading improvement in effluent removal and meeting consent limits.	Waste Water treatment	Waste Water Treatment	Neutral	1	1	1	1	1	1	2	3	*M	Biological Processes performance would improve with rise in concentrated sewage inflow.	Less issues with freezing pipework/ equipment and sewage temperature will be higher leading to better nitrification. Tightened consents due to the removal of summer / winter consents. Sewage Treatment Strategy Manager
20	High Temperature	Faster biological processes in river	Poor river quality leading to tighter consents	Waste Water treatment	Waste Water Treatment	Threat	1	3	3	2	3	6	9	3	#M	At higher temperatures the river capacity to assimilate oxygen is reduced and may require more process control to meet consent limits.	At higher temperatures the rivers will accommodate less BOD and ammonia leading to tighter consents being applied. Sewage Treatment Strategy Manager
21	High Temperature	Increased levels of septicity lead to increased toxicity, reducing receiving water quality and increasing odour	Rise in odour complaints with the potential deterioration in community relations.	Waste Water treatment	Waste Water Treatment	Threat	2	2	4	2	2	4	8	0	#L	Rise in odour complaints can be a concern but is dependent on wind direction and public tolerance to odour. Odour issues do not affect servicability and current monitoring plans sufficiently tackle the problem.	Increased summer temperature combined with low water levels could lead to higher odour complaints. Odour complaint data can be analyzed. In relation to temp. Odour complaints data does not provide accurate time/site locations/temp. Confirmed with Sewage Treatment Strategy team.
22	High Temperature	Increased levels of septicity lead to increased toxicity, reducing receiving water quality and increasing odour	Rise in odour complaints with the potential deterioration in community relations.	Waste Water Network	Sewer Network and Pumping Stations	Threat	2	2	4	3	2	6	10	0	#L	Rise in odour complaints can be a concern but is dependent on wind direction and public tolerance to odour.	Increased summer temperature combined with low water levels could lead to higher odour complaints. Odour complaint data can be analyzed. In relation to temp. Odour complaints data does not provide accurate time/site locations/temp. Confirmed with Sewage Treatment Strategy team.

23	High Temperature	Temperature rise will lead to decrease in dissolved oxygen in ASPs.	Excess oxygen will required for ASP treatment process, leading to rise in energy consumption.	Waste Water treatment	Waste Water Treatment	Neutral	1	2	2	2	2	4	6	3	*M	The overall treatment process will remain unaffected	Summer temperature effects ASP process by reducing dissolved oxygen requiring addition of oxygen, requiring excess energy. Consultation with Senior Asset Strategist.
24	High Temperature	Rise in temperature.	Fly/Mosquito impact.Still water in storm tanks and filters.	Waste Water treatment	Waste Water Treatment	Threat	2	2	4	2	2	4	8	1	#L	Score revised as servicability is not affected. Current monitoring sufficiently tackles odour and nuisance issues.	Stagnant water in storm tanks coupled with temp rise could increase fly/ mosquito population leading to rise in malaria cases. STFS 2005 data suggests rise in fly complaint between May and June. Waste workshop. STFS data acquired from Strategy
25	High Temperature	Rise in temperature.	Decrease in energy/heat loss but no increase in bio gas. Reduction in OPEX	Sludge	Digestion	Neutral	1	1	1	1	1	1	2	2	*M	Higher surrounding temp likely to reduce heat loss but will not result increase in biogas.	Digestors temps will not increase from higher summer temps due to insulation. Heat loss will decrease from digestor to CHP engines due to insulation. Confirmed by Renewable Energy Manager
26	High Temperature	Rise in humidity/temperature.	Increase in bio-gas moisture content could put CHP energy generation process at risk	Sludge	CHP	Threat	1	2	2	2	2	4	6	1	*M	Considered low risk.	Condensation within the gas pipework can lead to issues within the CHP engines. Solution in progress for Minworth. Waste Water Workshop
27	High Temperature	Rise in temperature.	Effect on CHP heat transfer or shutdown due to overheating.	Sludge	CHP	Threat	1	2	2	2	2	4	6	1	*L		Potential impact of CHP overheating due to high summer temperatures. Data/Evidence Source
28	High Temperature	Rise in temperature.	Increase in Sludge recycling in summer	Sludge	Sludge Application	Opportunity	1	1	1	1	1	1	2	2	*M	Warmer summers will allow application of sludge to land for a longer period, hence reducing storage requirements.	The recycling window could be extended due to drier land to recycle sludge. Peer review from Energy Management team.

A3.3 Support Services

Ref #	Climate Effect	Climate Impact	Consequence	T/O/N	Proximity vs. likelihood			Impact			Overall Risk Rating	Comments	Data/Evidence Source	Confidence	Pedigree
					Proximity vs. likelihood	Likelihood	Total	Population	Severity	Total					
Climate Driver: Change in Summer Temperature and precipitation															
1	Hotter drier summers	Reduced water availability.	**Supply Chain.** Suppliers have insufficient water for their processes. essential supplies not available when required	Threat	5	5	25	1	3	3	28	**SUPPLY CHAIN** Risk suppliers have been identified and a process is in place to discuss with them threats as they arise (e.g. this was used for swine flu). All suppliers who are single source of supply are included; where possible we have identified mitigating actions such as identifying an alternative supplier or alternative product. In addition, the reorganisation of the P&SC to focus on category management should lead to buyers having a more in depth expertise in relation to their area of the market, thus giving them more insight into the risks facing certain sectors and/or suppliers. At present it is considered that the timescale for impact is too far away to obtain useful information from our suppliers so we are concentrating on contingency planning / preparedness but as and when the operational part of the business requires more detail we can analyse the most critical supplier in more detail. (Including identification of where components are sourced from overseas to cover risk from disruption to transportation systems?)	Discussion with Purchasing and Supply Chain	M	1
2	higher average summer temperatures	Power supply infrastructure affected by over heating. Power failure during times of peak cooling demand	**Supply Chain.** Increased reliance upon stand by generators and renewable energy. Failure of operations in grid import fails. Summer Triads	Threat	5	5	25	1	5	5	30	Currently generating 20% of energy requirement from renewable sources, increasing to 30% by 2014. Renewable power can't be generated if there is power failure unless there is a back up-generator. Increases reliance upon stand by generators. Many sites, but not all have either dual, independent power suppliers or back up generators. In addition we have portable substation which can generate 6MVa that can be deployed in emergency situations. Unlikely to affect entire operation.	E&C Management.	M	1
3	higher average temperatures	Increase in heat exhaustion of staff.	**Staff H&S.** key members of staff absent or insufficient resources available. Operational disruption. Potential financial loss due to increased staff absence. Increase operational cost due to required additional building cooling.	Threat	4	5	20	2	3	6	26	**STAFF H&S:** contacting HPA to identify national data on anticipated trends for increase in diseases / adverse health effects which can be applied to our staff in order to quantify the potential risk. UKCIP - ca. 50 days over 25 degrees C by 2040s. Increase number of heat waves expected in 2020s+	DoH. 2008. Health Effects of Climate Change in the UK 2008	M	1

4	higher average temperatures	increase in adverse effects on older staff members	**Staff H&S.** key members of staff absent or insufficient resources available. Operational disruption. Potential financial loss due to increased staff absence. Increase operational cost due to required additional building cooling.	Threat	4	5	20	1	3	3	23	as above re STAFF H&S	DoH. 2008. Health Effects of Climate Change in the UK 2008	M	1
5	higher average temperatures	operational or support sites becomes too hot for staff to work	**Staff H&S.** key members of staff absent or insufficient resources available. Operational disruption. Potential financial loss due to increased staff absence. Increase operational cost due to required additional building cooling.	Threat	4	5	20	1	3	3	23	**PROPERTY:** our new STC has been built to the highest environmental standards currently available (BREEAM standards). Our depot strategy considers risks to sites (e.g. flooding) when deciding where to locate offices. At present no other action is ongoing to mitigate this risk.	Property rolling business plan.	M	1
6	higher average temperatures	increase in vector borne disease	**Staff H&S.** Increase in malaria, ticks and lymes disease. Key members of staff absent or insufficient resources available	Threat	1	2	2	1	4	4	6	Loss of staff time due to illness related for vector borne disease. Health Sector CCRA report indicates an increase in ticks and lymes disease and malaria, but latter likely to be a lower public health risk in the UK.	DoH. 2008. Health Effects of Climate Change in the UK 2008	M	1
7	higher average temperatures	conditions affect staff ability to work	**Supply Chain**. Conditions affect suppliers staff leading to essential supplies not available when required.	Threat	4	5	20	1	3	3	23	clauses in supply contracts to ensure continuity of supply - although not necessarily specifically related to climate change	Purchasing & Supply Chain	M	1
8	higher average temperatures	Reduced performance or failure of ICT equipment	**ICT**. Operational disruption. Increased costs for additional cooling, which also puts additional pressure on power supply.	Threat	3	1	3	5	4	20	23	No issues with server over summer 2010. Monkspath likely to be outsourced in either 2011 or 2016 (depending on lease break) this needs to be built into the contract of the new operator. Will affect entire Company	experience in 2010	M	1
9	higher average temperatures	Reduced reliability of Telecoms' infrastructure	**Telecoms'**. Impact on business continuity and operational disruption. Increased costs on maintenance and upgrading. Increased need for cooling.	Threat	3	3	9	4	4	16	25	No issues with server over summer 2010. Monkspath likely to be outsourced in either 2011 or 2016 (depending on lease break) this needs to be built into the contract of the new operator. Loss of systems will affect whole company. Monkspath supplied by 2 sources and 2 suppliers to ensure continuity of supply	experience in 2010	M	1
10	higher average temperatures	Reduced reliability ICT infrastructure	**ICT**. Impact on business continuity and operational disruption. Increased costs on maintenance and upgrading. Increased need for cooling.	Threat	3	1	3	5	4	20	23	No issues with server over summer 2010. Monkspath likely to be outsourced in either 2011 or 2016 (depending on lease break) this needs to be built into the contract of the new operator. Loss of systems will affect whole company. Monkspath supplied by 2 sources and 2 suppliers to ensure continuity of supply	experience in 2010	M	1
10	higher average temperatures	Change to working patterns and energy demand	**General** hotter temperatures may lead to workforce starting earlier and finishing later with a longer afternoon break.	Neutral	1	3	3	5	1	5	8	hotter summer temperatures may lead to a work pattern similar to southern Europe/tropics with early starts and later finishes but with a "siesta"	Suggested un UKCCRA and UKCIP Climate Change Impacts on Businesses 2009	L	1

11	higher temperatures and longer growing season	Increased length of pollen season. Earlier start to pollen season	**Staff H&S** Loss of productivity. Increased staff absence due to hay fever and/or pollen related asthma. Lost working days.	threat	3	3	9	1	2	2	11	Longer growing season due to warmer temperatures and possible higher pollen concentrations. Possible new pollens to which people are not used to. May all lead to increased incidences of hay fever or pollen induced asthma or more severe incidences.	DoH. 2008. Health Effects of Climate Change in the UK 2008.	M	1
12	Higher average temperatures & increase hours of sunshine. Lower cloud cover	increased UV exposure and sun burn	**Staff H&S.** higher incidence sun burn and possible rise in skin cancer affecting staff ability to work and potentially leading to litigation. Possible loss of staff time.	Threat	5	4	20	1	5	5	25	2 degree rise in temperature may lead to 21% rise in skin cancer. Staff working on operational sites outside may be exposed to sun for longer periods of time (expect higher temperatures and less cloud cover as a result of climate change) increasing risk of skin cancer. H&S section of Company Intranet Streamline covers working in the sun.	DoH. 2008. Health Effects of Climate Change in the UK 2008	M	1
Climate Driver: Winter temperature and precipitation															
13	higher average winter temperatures	average temperature increased	lower energy bills for heating FM and operational sites	Opportunity	3	4	12	5	4	20	32	Warmer winters should reducing heating requirements of buildings. This will reduce gas/oil/electricity consumption leading to an opex saving and a reduction in carbon footprint. Threshold detector shows fewer days when heating required in all season (particularly summer, spring and autumn)	E&C management. Monthly tracking of energy data.	M	1
14	wetter / warmer atmosphere	increase in algal or fungal growth in buildings	**Staff H&S.** Increase in respiratory problems. Key members of staff absent or insufficient resources available	Threat	1	2	2	1	2	2	4	Increase in respiratory diseases noticed after Lewes floods.	DoH. 2008. Health Effects of Climate Change in the UK 2008	L	1
15	Warmer winters/decreased snowfall	Reduced frost and snow cover. Less winter gritting	lower cost of gritting and reduced man hours lost to delays / inability to travel	Opportunity	4	4	16	4	2	8	24	Fewer cold days are predicted. Staff access to site (either office based or operational) should, therefore be easier with reduced risk or absence.	Large numbers of staff absent form work over winter 09/10 due to snow/ice	M	1
16	wetter / warmer atmosphere	increase in epidemic and systemic disease	**Logistics.** travel restrictions to disease infected areas affect ability to access our sites or affect our staff's ability to get to work	Threat	1	2	2	1	3	3	5	as above re STAFF H&S		L	0
17	higher average hours of sunshine	increased UV exposure	**HR/H&S.** higher incidence of skin cancer affecting staff ability to work and potentially leading to litigation	Threat	1	4	4	1	5	5	9	As above re STAFF H&S. Ozone layer thinner in spring, Therefore warmer winters and possible cloud free therefore higher risk than previously.	DoH. 2008. Health Effects of Climate Change in the UK 2008	M	1
Climate Driver: changes in annual, seasonal or daily precipitation															
18	increased localised flooding	suppliers unable to access sites and continue production	**Supply Chain.** essential supplies not available when required	Threat	4	4	16	1	4	4	20	as above re SUPPLY CHAIN		M	1
19	increased localised flooding	operational or support sites inaccessible	**Logistics.** unable to continue normal operations at these sites	Threat	4	4	16	1	4	4	20	As above re PROPERTY. Desktop refresh should help mitigate this as staff should be able to work anywhere.	Review with Property and IS	M	1
20	increased localised flooding	increased travel disruption	**Logistics.** key members of staff absent or insufficient resources available	Threat	4	3	12	1	3	3	15	Flooding reduces accessibility. Desktop refresh should allow access anywhere, not just STW sites.	Experience in 2007	M	1

21	reduced raw water available coupled with increased localised flooding	increased sewer flooding and increased hosepipe bans	**HR/H&S.** impact on staff stress levels / mental health	Threat	4	4	16	1	2	2	18	as above re STAFF H&S		M	1
22	variations in water quality	increase in water borne / gastro-intestinal diseases	**HR/H&S.** key members of staff absent or insufficient resources available	Threat	4	4	16	1	3	3	19	as above re STAFF H&S		M	1
23	increased precipitation and intensity	increased localised flooding	**Logistics.** travel disruption and/or ability to recruit in the areas where we need staff impacts on our ability to adequately resource our operational sites	Threat	4	4	16	1	3	3	19	Having right resources and right staff in right place at right time.	Experience in 2007	M	1
24	Increased precipitation leading to increased flooding	Increased insurance claims for property damage	**Insurance.** Increased cost of premiums	Threat	4	4	16	1	3	3	19	2 degrees C rise in temp may lead to ca. 10-15% rise in 1-100 year flood event. 4 degrees C rise may lead to 20-25% rise in 1-100 year flood event. Costs also dependent upon market conditions. Check John Lee and Jo about changes post Mythe and going forward and what market is likely to do.	ABI (2009) ABI Research Paper 19. The Financial Risks of Climate Change	M	1
24	increased incidence of extreme precipitation events	flood damage or subterranean damage to telecoms equipment/infrastructure	**Telecoms'.** Temporary breakdown in telecoms. Increased operational costs. Unable to carry on normal activities, affects customers ability to contact us.	threat	4	2	8	3	5	15	23	Procedures in place to ensure continuity of supply.	Cabinet Office Critical national Infrastructure report	M	1
30	increased incidence of extreme precipitation events	flood damage or subterranean damage to ICT equipment/infrastructure	**ICT.** Temporary breakdown in telecoms. Increased operational costs. Unable to carry on normal activities, affects customers ability to contact us.	threat	4	2	8	3	5	15	23	Procedures in place to ensure continuity of supply.	Cabinet Office Critical national Infrastructure report	M	1
31	increased incidence of extreme precipitation events	Flood damage to power infrastructure	**Power failure.** Operational failure. Increased reliance upon back up generators. Need for increased fuel storage	threat	5	3	15	1	5	5	20	Currently generating 20% of energy requirement from renewable sources, increasing to 30% by 2014. Renewable power can't be generated if there is power failure unless there is a back up-generator. Increases reliance upon stand by generators. Many sites, but not all have either dual, independent power suppliers or back up generators. In addition we have portable substation which can generate 6MVa that can be deployed in emergency situations. Unlikely to affect entire operation.	Cabinet Office Critical national Infrastructure report. E&C Management Team	M	1
Climate Driver: increasing variability of weather															
32	increased storm conditions, increased extremes of weather	suppliers unable to obtain components from overseas	**Supply Chain.** essential supplies not available when required	Threat	3	3	9	1	4	4	13	as above re SUPPLY CHAIN		L	1
33	Increase in windstorms/gales	damage to above ground telecoms infra structure	**Telecoms'.** Operational disruption. Potential financial loss. Inability to communicate	Threat	4	2	8	3	5	15	23	Increased storminess, such as stronger winds and rain may damage above ground equipment. But procedures in place to ensure continuity of supply	Purchasing & Supply Chain	L	1

34	Increase in windstorms/gales	damage to above ground ICT infra structure	**ICT** operational disruption. Potential financial loss. Inability to communicate	Threat	4	2	8	5	4	20	28	increased storminess, such as stronger winds and rain may damage above ground equipment but s suppliers/sources at Monkspath thereby reduces the risk		L	1
35	Increase in windstorms/gales	Damage to power supply	**Power Supply.** Operational disruption. Potential financial loss. Inability to communicate	Threat	2	3	6	1	5	5	11	Currently generating 20% of energy requirement from renewable sources, increasing to 30% by 2014. Renewable power can't be generated if there is power failure unless there is a back up-generator. Increases reliance upon stand by generators. Many sites, but not all have either dual, independent power suppliers or back up generators. In addition we have portable substation which can generate 6MVa that can be deployed in emergency situations. Unlikely to affect entire operation.	E&C Management	L	1
36	increased magnitude of extreme winter events (snow/ice/fronts)	Increased risk of slips/trips and falls due to ice	**HR/H&S**. Loss time incidents, staff absence, impact on operations. Potential increased litigation.	Threat	2	1	2	1	3	3	5	Although the projections infer warmer winters there may be cold events where our ability to cope is reduced due to their infrequency. We may therefore have less grit on site and would be more at risk from slips/trips/falls in icy conditions.	Indicated in UKCCRA	M	1
37	More extreme weather events. Increased in wind.	Damage to infrastructure, leading to increased insurance claims	**Insurance.** increased premiums	Threat	2	2	4	1	3	3	7	Possible 10-17% rise in 1-100 year wind storm event. Leads to rise in insurance claims and therefore cost of claims. Costs also dependent upon market conditions. Our premiums based on entire business not individual sites.	ABI (2009) ABI Research Paper 19. The Financial Risks of Climate Change	M	1
Climate Driver: changing wind patterns															
38	increase in tropical air borne diseases	increased staff absenteeism through exposure to increased airborne infection	**HR/H&S**. key members of staff absent or insufficient resources available	Threat	1	2	2	1	3	3	5	as above re STAFF H&S		L	1
39	Windstorms/gales	personal injury to staff	**Staff H&S**. key members of staff absent or insufficient resources available	Threat	1	2	2	1	3	3	5	New probabilistic projections of windspeed produced too late to do any significant analysis, but wind speeds projected to reduce or have near-zero change. May be extremes in natural variability.		L	1

Appendix 4. Options Identification and Appraisal

The stages in our methodology for assessing the investment needed to reduce the impact of major asset failures are detailed below:

- Step 1- The development of a complex model of our strategic grid to assess the impact of failures on our customers.
- Step 2 - Identification of failure events and mitigation schemes options
- Step 3 – Model sensitivity analysis
- Step 4 – Cost Benefit Analysis (CBA)
- Step 6 – CBA / Willingness to Pay sensitivity analysis
- Step 7 – Timing of investment

Full details of our risk assessment methodology along with a detailed description of each of the resilience schemes to be implemented over AMP5, and the benefits they will provide, can be found in our Final Business Plan, Chapter A and B6.

This appendix provides more detail on the options identified and appraised by water and waste water to manage the projected impacts of climate change.

A4.1 Water

We have shown in Section 3.1 that one of the highest ranking risks to Water Services were the effects of low summer precipitation and high summer temperatures on river and groundwater ecology. The consequence of these risks would be to restrict our ability to abstract water during summer periods. During our review of these risks, a wide range of potential adaptation responses were identified to help mitigate the climate change impacts: (see Section 5.1.2).

- Vary existing abstraction licences to allow us to take water when we need it (increase the peak but decrease the annual licence)
- Vary existing abstraction licences to avoid daily licence breaches (e.g. increase the peak for a certain number of days over a period of time)
- Purchase obsolete licences in the area of concern
- Transfer of our own abstraction licences in the same Groundwater Management Unit from abandoned or disused sites to those that require it
- Lay new pipelines to allow transfer of water from surrounding sources
- Extend the strategic grid
- Increase raw water storage
- Build small reservoirs to support the river or specific abstraction sources. This water could be used for supporting the river level and also for water quality purposes (dilution of treated sewage effluent in river and also dilute river water)
- Increase dam height of current reservoirs
- Utilise other rivers in our area
- Move source (within groundwater unit)
- Find alternative source where there is less pressure on the water resources
- Dig compensation boreholes to provide augmentation flows to rivers and water courses under stress

- Build new treatment works
- Take water from canal or other water course to support the abstraction (to compensate river)
- Reduce demand (e.g. targeted leakage management, metering)
- Reducing compensation releases in the summer – variable compensation regimes
- Use of “Pump back schemes” – compensation releases are made from reservoirs then the water is abstracted a few miles downstream. This protects the stretch of river
- Reduce demand – ideally voluntarily but otherwise through legislation (compulsory metering)
- Metering – making customers pay for volume used
- Reduce leakage though increased investment in infrastructure
- Educate customers to reduce demand
- Invest and plan for grey water
- Influence planning standards for new build
- Lobby to increase penalty for people breaking hosepipe ban
- Introduce rotas for hosepipe use
- Introduce rising block tariffs for water use during summer months
- Service level agreements may need to be negotiated
- Educated shareholders and exec on nature of climate change risks – might need to adjust expectations of the company as a whole
- Targets to reduce demand over five years
- Train more personnel to stop leaks – skills shortage
- Ofwat’s management of leakage reduction – ensure all parties work together so no gaps in funds and expectations
- Profile of leakage activity could change e.g. work at night when system is quieter
- Increase number of operational staff
- Better understand contractors available and how to work together
- Multi-skilled staff e.g. metering team can work on leaks in “down time”

Following the methodology outlined in Appendix 1 we have begun to analyse the available options, allowing us to focus the detailed cost / benefit assessment on the most feasible:

Table A4.1 Assessment of the option to introduce rising block tariffs during summer months

Criteria	Score
Flexibility	3
Sustainability	2
Equity	1
Cost	3
Acceptability	1

Effectiveness	1-2
Timing	2
Coherence	3
Robustness	3
Total	**19 - 20**

Table A4.2 Assessment of the option to develop a new storage reservoir

Criteria	**Score**
Flexibility	1
Sustainability	2.5
Equity	3
Cost	3
Acceptability	1.5
Effectiveness	3
Timing	1.5
Coherence	2
Robustness	3
Total	**20.5**

A4.2 Waste Water

Having identified our priority risks we conducted a series of workshops to continuously engage with our field operators and business specialists to incorporate their experience in validating the highest risks identified in our risk matrix (Appendix 3) and developing suitable mitigation options for consideration in our future business plans. Following the options identification and appraisal methodology outlined in Appendix 1 we identified a number of options to manage sewer flooding, which are detailed in Appendix 4.

- Surface water separation. (Committed In Amp5 and SDS)
- Rise in onsite storage at CSOs.
- Pass higher vol water to STW.
- Improve discharge quality by improving treatment process. (High Capex and High Carbon solution)
    - chemical
    - UV
    - Natural.
- Demand Management (grey water recycling from domestic/commercial consumers) Committed in AMP5 Water plan.
- SUDS. (Committed in SDS). NS- Lobbying LA's/Gov to promote SUDS
- Integrated urban planning models. (Committed in AMP5).

- Empty STW storm tanks into river to enable collection of higher flow levels.
- Remove surface water sewers – manage on surface. Can't Retrofit.
- Can we put a value against releasing head room in sewers by removing surface water to put in CBA for PR14?

Table A4.3, below shows the appraisal scores for raising the volume of water passed to treatment works and increasing the onsite storage.

Table A4.3 Assessment of options for increase storage capacity and passing greater volumes to treatment works

Criteria	**Score**
Flexibility	1
Sustainability	1
Equity	1
Cost	1
Acceptability	2
Effectiveness	3
Timing	2
Robustness	1
Total	**12**

Table A4.4 shows the appraisal scores for the use of sustainable urban drainage systems.

Table A4.4 Assessment of sustainable urban drainage systems

Criteria	**Score**
Flexibility	3
Sustainability	3
Equity	3
Cost	3 on new development 1 on retro fit
Acceptability	3
Effectiveness	3
Timing	3
Robustness	3
Total	**24 (22 on retrofit)**

Initial workshops were held in August 2010, prior to the establishment of the final methodology devised on the 2nd September in association with UKCIP, as outlined in Appendix 1. These workshops brought together operational experts from around the business to identify possible mitigating action and time scales for implementation as well as stakeholders and interdependencies. The outputs from the sessions are below

Risk
Higher winter precipitation & higher storm intensity leading to Sewer hydraulic capacity (Sewer flooding)

Impact	**Interdependencies**	**Stakeholders**	
		Internal	**External**
More flooding of customer properties More sever flooding More combined sewer overflow discharges Damage to Brand Loss of customer confidence Fines Compliance with serviceability measure	Local Authorities Ofwat & EA (Flexible regulation)	Asset Creation New Connections Standards Service Delivery P&P Sewage Treatment Commercial Services (Trade Waste)	Local Authorities Planners SUDS Approval Body Surface water management Ofwat CCW Customers Developers EA Natural England (SSSI) IDB

Possible Actions	**Timescale**	**How to Monitor**	**Barriers**
Build more capacity in: Pipes Storage	AMP 5	Continue to model sewer systems Model climate change Research and use results Serviceability performance Legal requirements Monitor silt levels	Confidence in UKCP09 results Willingness to pay for uncertain future risks Lack of central direction (both internal and external) Diverse responsibility for surface water management
Reduce connected area: SUDS Separate Influence customer behaviours	AMP 5		
Reduce infiltration	AMP 6		
Manage exceedance flows	AMP 5		
Manage customer expectation	AMP 5		

Risk
Higher Summer temperatures leading to faster biological process in the river

Impact	Interdependencies	Stakeholders – Internal	Stakeholders – External
Poor river quality leading to tighter discharge consents High EVA pollution Less precipitation Low dilution rate of sewage treatment works discharge Low dissolve oxygen in river due to flow and higher temperature High impact on aquatic life Requirement to meet River Quality Objective by tightening consents Failure to meet SAC target levels	Who measures the data & where? EA/Ofwat (willingness of regulator to engage in conversation)	TERI/ESCADA/ICA Teams Consenting Teams Sewerage and Sewage Treatment Water Strategy Commercial Waste (TTE) Energy & Carbon	EA Defra Ofwat British Waterways Natural England

Possible Actions	Timescale	How to Monitor	Barriers
Work with EA on river flow levels to understand true picture	AMP5	River Quality Objective River DO River ammonia River consent data River flow Discharge consents Works flow	Asset life Sewerage Network (Combined) EA (Regulators)
Prevent over treatment	AMP 6		
Understand what data are available and where	AMP 6		
Variable consent/catchment consent (SIMCAT)	AMP 5		
Improving interaction with the EA	AMP 5		
Working with water to recycle effluent from treatment works (grey water)	AMP6		
Competition – remote requirement for point consenting, lower whole life cost	AMP 5		
More P removal from effluent	AMP 5		
Removal of river flora	AMP 6		

<table>
<tr><td colspan="4">Risk</td></tr>
<tr><td colspan="4">Higher winter precipitation and higher storm intensity leading to overwhelming of the treatment process</td></tr>
<tr><td rowspan="2">Impact</td><td rowspan="2">Interdependencies</td><td colspan="2">Stakeholders</td></tr>
<tr><td>Internal</td><td>External</td></tr>
<tr><td>Overwhelming the inlet works (flooding/screening – operational costs)
Backing up of sewage system
Sites with Storm tanks
Increased flow to river
Backing up of sewer
Nuisance issues
Damage/ destruction of plant/works
Non-complaince with permits
Sites with no storm tanks
Can’t control process
Final effluent quality is impaired
Site flooding
Nuisance
Increase environmental pollution
Non-compliance with permit
Inability to manage sludge</td><td>Ofwat
Customers (willingness to pay)</td><td>Asset Creation
Strategy
P&P
Service Delivery
Sewerage - network impacts</td><td>Environment Agency (consent/permit)
Ofwat (funding)
Customers</td></tr>
<tr><td>Possible Actions</td><td>Timescale</td><td>How to Monitor</td><td>Barriers</td></tr>
<tr><td>Procedures that work in place</td><td>AMP 5</td><td rowspan="11">Repeated modelling of precipitation and temperature
Monitoring storm tank spill frequencies
Model storm tank route
Storm tank spill data</td><td rowspan="11">Gaining funding
Cannot control inflow
Changing consents</td></tr>
<tr><td>Trained operators</td><td>AMP 5</td></tr>
<tr><td>Apply for storm consents and build storm tanks</td><td>AMP 6</td></tr>
<tr><td>Increase network capacity and/or storm tank</td><td>AMP 6</td></tr>
<tr><td>Build levees/flood barriers around vulnerable sites</td><td>AMP 6</td></tr>
<tr><td>Elevate electrical items</td><td>AMP 5</td></tr>
<tr><td>Develop flood plains (reed beds)</td><td>AMP 6</td></tr>
<tr><td>Manage inflow (separation and SUDS)</td><td>AMP 5 & 6</td></tr>
<tr><td>Storm tank emptying procedures</td><td>AMP 5</td></tr>
<tr><td>Incorporate climate change into Design standards</td><td>AMP 5</td></tr>
<tr><td>Consider flood levels</td><td>AMP 5</td></tr>
</table>

On the 2nd of September a number of other options were identified and then formally appraised using the methodology in Appendix 1.

Impact
Higher summer storm intensity leading to rising CSO levels and lower water quality.

Known concerns:

Little (no collated data on CSO no. / year.

EA approval:- Need to know load room, steepness of catchment, length of sewer, population size and precipitation to devise regional solutions.

Options

1. Surface water separation. (Committed In Amp5 and SDS)
2. Rise in onsite storage at CSOs.
3. Pass higher vol water to STW.
4. Improve discharge quality by improving treatment process. (High Capex and High Carbon solution)
    a. chemical
    b. UV
    c. Natural.
5. Demand Management (grey water recycling from domestic/commercial consumers) Committed in AMP5 Water plan.
6. SUDS. (Committed in SDS). NS- Lobbying LA's/Gov to promote SUDS
7. Integrated urban planning models. (Committed in AMP5).
8. Empty STW storm tanks into river to enable collection of higher flow levels.
9. Remove surface water sewers – manage on surface. Can't Retrofit.
10. Can we put a value against releasing head room in sewers by removing surface water to put in CBA for PR14?

Higher summer storm intensity leading to rising CSO levels and lower water quality. (Option 2,3 &4)

Criteria	Comments	Score
Flexibility	Can't build tanks of variable size one off. Can't incrementally plan.	Low (1)
Sustainability	Surface Water separation is better. High embodied carbon	Low (1)
Equity	Higher cost to customers & shareholders. Disadvantage to immediate neighbours (odour tankers, etc)	Low (1)
Costs	High capex Lower Opex	Low (1)
Acceptability	Not to EA. Possibly acceptability by customers.	Medium (2)
Effectiveness	Proven to work	High (3)
Timing	Reactive investment to current issues. Can be quickly implemented	Medium (2)
Robustness	Solves immediate problem BUT not incremental once it is full.	Low (1)

Higher Summer Storm – rise in Sewer Flooding. Surface Water separation SUDS (Options 1 & 6)

Criteria	Comments	Score
Flexibility	Need to apply to development & redevelopment. But where to put it? As per 2/9/2010, ******* Can build incrementally, but not good at dealing with specific event:- Not immediate/reactive Can focus on least risk areas:- can be prioritized Aligned with climate change	High (3)
Sustainability	SEPARATION - Negative impact on river system High Capex and carbon SUDS – No negative impact on river.	Med (2) High (3)
Equity	SUDS – Good neighbour.	High (3) SUDS Med (2) SEPA
Costs	Who pays? – can transfer cost to developer Who maintains? High cost to retrofit – STW Ltd. Pay and Transfer Only done where cost effective for customer.	High (3) on development Low (1) on retrofit
Acceptability	SEP - Less acceptable impact on river. SUDS - But less flooding of properties and less river pollution	Med (2) High (3)
Effectiveness	Its functions well.	High (3)
Timing	Apply to development and redevelopment Can target delivery based on models. Long term plan Better case for AMP6 Planned approach	High (3)

Impact & Consequence

- Higher temperatures bring about increased levels of septicity lead to increased toxicity, reducing receiving water quality and increasing odour. This may lead to an increase in the number of odour and nuisance complaints

Options

1. Customers more likely to complain irrespective of climate change – may have to deal with it anyway
2. Limit development around STW's – liaison with planners
3. Move STW's to remote areas
4. Chemical dosing/covered tanks – traditional odour control methods such as filtration
5. Tree planting as a natural barrier
6. Diverting odour/dilution/scrubbing
7. Different treatment methods to reduce odour and insect larvae
8. Do nothing – requires customer engagement and agreement
9. Engage with developers up front (developer bears cost)
10. Investment in odour modelling and forecasting
11. Identify trigger levels and circumstances in which to turn odour control on
12. Temperature measurement (and forecast) linked to odour control and engaging with customers
13. Record specific odour complaints (when, conditions, repeated) to build up data to help predict and forecast
14. Wind characteristics to help inform developers (prevailing wind direction)
15. Knowledge of industrial customers and impact of their discharge on odours (can we have a similar approach to discharge consent as Triads?)

Criteria	Comments	Score
Flexibility	If invested in odour control we can change. We can move quickly to cover/reduce odour if we have advanced notice. Some flexibility for some options	Reasonable (2)
Sustainability	Site dependent. Operational costs outweigh capital costs. Life time of covers is variable (depends upon material). Can be energy intensive. "Band aid" rather than cure	Low to medium (1-2)
Equity	Depends upon reactivity	High (3)
Costs	High Opex (energy & chemicals). Not win-win. Not solving the problem just masking it.	Low (1)
Acceptability	Not mutually acceptable. Health and Safety concerns. Cost could be passed to customers (WTP)	Low (1)
Efficiencies	Pretty efficient. Technically feasible	High (3)
Timing	Quick installation of kit and of fixed kit. May need to up skill staff	High (3)

Appendix 5 – Stakeholder Engagement

This Appendix outlines the previous work we have undertaken to engage our stakeholders in our future plans. It the provides more detail on some of the work we have undertaken as part of this risk assessment.

A5.1 Engagement to develop our future plans

Climate change adaptation is already embedded in our AMP 5 plans. These plans were not developed in isolation, but through consultation and engagement with:

- Customers through market research to understand their willingness to pay for future improvements
- Our regulators to ensure that statutory and regulatory requirements are met
- Other stakeholders who may be affected by our plans or in turn may affect us

We regard stakeholder engagement and consultation as a fundamental part of the process to develop of our plans. On a regular basis, we also meet with a range of stakeholders – such as the EA, DWI and Ofwat - to discuss how we are delivering against those plans.

Working with our stakeholders is very much part of ‘business as usual’. We detail some of the key elements of our consultation and engagement below.

A5.1.1 Strategic Direction Statement (SDS)

The potential impact of climate change is an explicit consideration in our longer term strategy. ‘Focus on water’ our 25-year SDS, considers how climate change could impact on our operations, our customers and the environment.

We consulted extensively on our draft SDS before finalising it. Using a combination of written consultation and face-to-face meetings, we sought the views of a range of different stakeholders including:

- the Environment Agency (EA);
- the Drinking Water Inspectorate (DWI);
- Department for Environment, Food and Rural Affairs (Defra);
- Ofwat;
- the Consumer Council for Water (CCWater);
- the Countryside Commission for Wales;
- Natural England;
- Investors; and
- MPs.

We also took account of the views of our customers through market research which were carried out with our domestic and business customers including a ‘Willingness to Pay’ survey in 2007. This involved interviews with 1,000 domestic customers and nearly 500 business customers, to establish customers’ priorities and their willingness to pay for improvements in the different areas of our service provision.

A5.1.2 Water Resources Management Plan (WRMP)

Our WRMP sets out how we intend to provide a continuous supply of high quality water to our customers over the next 25 years and beyond. The WRMP explains the challenges we face and considers the vulnerability of our supply system to climate change impacts and uncertainties. It explains the range of options open to us to ensure that we can meet the future demand for water, and it sets out our strategy.

We published our draft plan for consultation in May 2008. Thirteen different stakeholders including county councils, the National Trust, Countryside Council for Wales and the EA responded to our public consultation. We published a statement of response in February 2009 setting out how we had amended our plans in the light of issues raised. We published our final plan in the summer of 2010.

A5.1.3 Drought Plan

In June 2006 we published our draft Drought Plan on our website. In addition letters were sent to 130 organisations publicising the consultation. Twelve different stakeholders including Defra, Ofwat, Natural England, CC Water, the EA and five local authorities responded. We published our response to the consultation and these then incorporated into our final Drought Plan, which published in Summer 2007.

A5.1.4 2010-2015 Business Plan

Our 2010-15 Business Plan, in line with our SDS, identifies the need to adapt to climate change as a significant challenge. Following the guidance of Ofwat, our business plan used the UKCIP02 data which was the best available at that time. Also in line with Ofwat’s guidance, and given the uncertainties presented, our plan focuses on making incremental changes in the short term with the aim of continuously reviewing our approach in the light of new data.

We developed our business plan first in draft for wide ranging consultation during 2007, before submitting a final version to Ofwat in 2009. Both the draft and final plans were developed through a process of extensive customer research and stakeholder consultation:

We asked our customers about their priorities for the future and embedded ‘Willingness to Pay’ research in our plan. For example, they identified reliability of supply as a top priority. Our plan includes a number of resilience works in response.
We used extensive discussion with our regional ‘Quadripartite Group’ (consisting of CCWater, the EA, Natural England and the DWI) to ensure our plan reflected an appropriate balance of priorities.

A5.1.5 Development of local authorities’ surface water management plans (SWMPs)

The Flood and Water Management Act 2010 places new responsibilities on local authorities to coordinate regional flood strategies, and we expect to work with them particularly as the local partnership provisions of the Act come into effect in 2011.

We have already started to work with the ten Local Authorities in our area who were given funding by Defra to develop SWMPs. This includes, for example, sharing our hydraulic models which Local Authorities can use to identify areas of significant risk of flooding and allows us to prioritise investment in those areas as part of our sewerage management plans.

A5.2 Engagement for this risk assessment

Table A5.1 and Figure A5.1 show our identification and analysis of key stakeholders in the climate change risk assessment process. We have then used that analysis to help us begin to identify dependencies and interdependencies between us and our stakeholders (Table A5.2)

Table A5.1: Summary of climate change impacts and stakeholders affected

	Importance	Loss of telecoms	Loss of ICT	Loss of critical supplies (Chemicals	Loss of Critical Supplies (fuel)	Drought	tighter regulation	tighter abstraction	declining water quality	higher demand	Odour	sewer flooding	Combined Sewer Overflows	tighter discharge consents	flooding of assets	Removal of sludge from sites	sewer blockage
Customers (and their representatives e.g. MPs)	Reliant on our services. Their behaviour (e.g. usage) impacts availability of supply.					✓			✓	✓	✓	✓	✓		✓		✓
Local Authorities	Responsible for local flood risk management								✓	✓		✓			✓		✓
Other Water Cos	Face same challenges and on a national basis, compete for the same resources. Actions will impact our operations.					✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
Natural England	Protects the natural environment of England					✓	✓	✓	✓					✓	✓		
Ofwat	Economic regulator of the water industry.					✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
Energy Suppliers	Supplier of essential services.	✓	✓		✓												
Energy Infrastructure	Required for essential services.	✓	✓		✓												
Telecommunications	Supplier of essential services.	✓															
NFU/Members	Land managers impact on water quality and surface water run off					✓		✓	✓						✓		
Forestry Commission	Land managers impact on water quality and surface water run off					✓		✓	✓						✓		
National Forest	Land managers impact on water quality and surface water run off					✓		✓	✓						✓		
CC Water	Represent the interests of customers					✓			✓	✓	✓	✓	✓		✓		✓
DWI	Drinking water quality regulator					✓	✓	✓	✓								
Defra	Sets policy framework for the industry in England					✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
Wildlife Trusts	Contribute to management of catchments					✓	✓	✓	✓						✓		
Countryside Council for Wales	Protects the natural environment of Wales					✓	✓	✓	✓					✓	✓		
Welsh Assembly Government	Sets policy framework for the industry in Wales					✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
Suppliers	Provider of essential resources			✓	✓												
Sludge contractors	Provider of essential service															✓	

Table A5.2 STW's dependencies and interdependencies to manage priority climate change impacts

	Loss of telecoms	Loss of ICT	Loss of critical supplies (Chemicals	Loss of Critical Supplies (fuel)	Drought	tighter regulation	tighter abstraction	declining water quality	higher demand	Odour	sewer flooding	Combined Sewer Overflows	tighter discharge consents	flooding of assets	Removal of sludge from sites	sewer blockage
Local Authorities								I	I		I	I		I		I
Other Water Cos					I	I	I	I	I	I	I	I	I	I		I
Environment Agency					I	I	I	I		I	I	I	I	I		I
Natural England					I	I	I	I					I	I		
Ofwat					I	I	I	I	I	I	I	I	I	I		I
Energy Suppliers	D	D		D												
Energy Infrastructure	D	D		D												
Telecomms	D															
NFU/Members					I		I	I						I		
Forestry Authority					I		I	I						I		
National Forest					I		I	I						I		
CC Water					I			I	I	I	I	I		I		I
DWI					I	I	I	I								
Defra					I	I	I	I	I	I	I	I	I	I		I
Wildlife Trusts					I	I	I	I						I		
Countryside Council for Wales					I	I	I	I					I	I		
WAG					I	I	I	I	I	I	I	I	I	I		I
Suppliers			D	D												
Sludge contractors															D	
Customers					I			I	I	I	I	I		I		I

Critical dependency D   Critical Interdependency I

A5.2.1 Adapting to climate change – Severn Trent Water's response to the Climate Change Act's Adaptation Reporting Power. 11th November 2010

Aim of workshop
Severn Trent Water are looking to raise awareness of the work we have done to date on adapting to climate change, to understand how the operations of public sector bodies may be affected by our decisions and how their decisions and actions may affect us and to obtain feedback on our approach.
Objectives

1. Raise awareness within public sector bodies of the work that Severn Trent Water is currently undertaking on climate change.
2. To give public sector bodies the opportunity to comment on the findings from Severn Trent Water's climate change risk assessment and options identified to mitigate against the priority risks
3. For Severn Trent Water to understand the interdependencies with its key stakeholders within the East Midlands in relation to climate change
4. To give public sector bodies the opportunity to discuss how their operations may be affected by Severn Trent Water's operations and decisions in relation to climate change.

Target Audience
This work shop would be targeted at those working on climate change risk assessment and those directly involved with managing the impacts of climate change, such as planners and those working on surface water management.

Workshop Process
Ice Breaker – on arrival
On a flip chart there is a list of the organisations, including those present today, who Severn Trent Water have engaged with in developing the Adaptation report. Using post-its delegates should add to the list any other parties they think need to be involved (either at organisation level or person/department specific) and why. They can revisit this at any point in time during the workshop.

Overview
PowerPoint presentation on work carried out to date in reference to climate change
Breakout Session 1
Breakout into two groups: one for water and one for waste water. (four stations each)
Priority risks and all other risks for water, waste water and support services are documented on flip charts.
Facilitators are to briefly run through the risk assessment matrix – need to give **basic** understanding.
Delegates are given the opportunity to review the risk assessment and are posed the following questions:

5) How do these risks impact your organisation? (answer on yellow post-its)
    - Focus on priority risks first
    - Focus on other risks second
6) What are your organisation's priority risks? (answer on green post-its)

7) Are there any other significant risks that we haven't identified and if so what and why? (answer on pink post-its)

Answers to these questions should on post-its and stuck alongside the risk(s) to which they relate.

Delegates should have 35 minutes to review their chosen risk assessment (i.e. water or waste water). They should then be given the opportunity to review the other two risk assessments to answer the same questions.
Bring the group back together to have a 10-15 review of the discussions, this will also give people the opportunity to add any further comments

Breakout Session 2
Breakout into two groups: water or waste water (four stations for each)
Each group will have 2 priority risks for which a series of options to reduce those risks have been identified (those discussed and identified in the UKCIP workshop form the 2nd September). Facilitators are to run through these options and provide a **brief** of explanation.

Breakout session 2: Options identification and appraisal (on basis that we will be giving them a starter for 10):

1) What other options could be used to mitigate against the Severn Trent Water priority risks? (pink posits)
2) What options is your organisation putting in place to mitigate against climate change related risks? (orange post-its)
3) Looking at the options identified how can we work together on these options (ours and yours) to give the greatest benefit? (blue post-its)
4) What do we need to do to make this happen? (purple post-its)

Answers to these questions should on post-its and stuck alongside the risk(s) to which they relate.

Delegates will have 40 minutes to review their chose groups options (i.e. water or waste water) they should then be given the opportunity to review the other groups options.
Bring the group back together to have a 10-15 review of the discussions, this will also give people the opportunity to add any further comments.

Organisations represented at the workshop:

- Ashfield District Council
- Derby City Council
- Natural England
- Nottingham City Council
- North East Derbyshire District Council
- EM IEP
- Bassetlaw District Council
- Newark & Sherwood District Council
- Nottingham City Council
- Erewash Borough Council
- Derby City Council

- Derbyshire Dales District Council
- South Derbyshire District Council
- Northamptonshire County Council
- Leicestershire County Council
- Climate East Midlands

Climate East Midlands Evaluation
We were keen to ensure that the workshop on 11 November was beneficial both to us and to the attendees. We felt, therefore, that it was important to gain some structured feedback from the delegates in order to ensure they got value and that we could correct any issues in running other workshops. The evaluation questionnaire aimed to understand their initial level of understanding, their feelings on the risk assessment and on the options identification and appraisal. Respondents were asked to rate these items on a scale of one (poor/low) to five (fully/comprehensive). We also asked if they felt there were any other interested parties that we should be in contact with and if they wised to remain in contact with us. We only had eight responses to our evaluation questionnaire, we have nevertheless analysed these results. Responses came from three city councils, two borough councils, one county council and one regulator. (see Appendix X)

Question 2. Level of awareness
Delegates were asked about their level of understanding of our work on climate change prior to the workshop and afterwards. With the exception of one borough council, who showed no change, all respondents left the workshop with an improved understanding of our work on climate change.

Question 3 and 4. Quality of the risk assessment.
The majority of the respondents rated the quality of the risk assessment as 4/5. Three respondents did give any score, with all three commenting that as they only saw a summary they couldn’t really rate the risk assessment fully. They were also asked to rate their opportunity to comment on the risk assessment. The average score for this question was 4/5, with three giving a rating of 3/5 and one rating it 5/5. One of those who gave 3/5 would have liked more time to review the water waste water risk assessments as well as the water risk assessment.

Question 5. Opportunity to comment on adaptation options.
Delegates were asked whether they felt they were given enough opportunity to review, comment upon and help develop further options to manage climate change risk. The average score for each of these areas was 4/5, with all feeling that they had adequate opportunity to discuss and develop options and areas where we could work collaboratively to manage the impact of climate change. Two respondents would like to have further opportunity for discussion and collaborative working.

Question 6. Identifying interdependencies.
Delegates were asked whether they felt they had enough opportunity to indentify and express the key interdependencies between their organisation and us. The average score for this question was 4/5. Two respondents rated this area 5/5 and one rated it 2/5, although offered no explanation on why they felt they had not had enough opportunity to do so.

Six of the respondents were keen to remain in touch with us, three of which felt that the event had been useful.

Appendix 6 Defra/Cranfield Reference Guide

The following tables provide our response to the questions raised in Box 2 and Annex B of Defra's Statutory Guidance. We have also highlight the relevant attributes and sub-attributes from Cranfield University's evaluation framework and cross reference against the relevant sections in this report.

<table>
<tr><td colspan="3">1. Information on Severn Trent Water</td></tr>
<tr><td colspan="3">Name of Organisation. Organisation's functions, mission, aims, and objectives affected by the impacts of climate change
A summary of your organisational purpose and key strategic priorities which are or will be affected by climate change is important when identifying risks to your organisation.</td></tr>
<tr><td>Response</td><td>Relevant Cranfield Attributes</td><td>Reference to Relevant Section in STW Report</td></tr>
<tr><td>Severn Trent Water Ltd is one of the largest ten water and waste water companies in England and Wales. Our operational area covers an area of 21,000 Km^2 in the Midlands and mid-Wales and we provide water to 7.5 million people and sewerage services to some 8.5 million people.

Our Strategic Direction Statement (SDS), published in 2007 sets out our proposals to make improvements which meet customer needs, whilst ensuring that we have a sustainable impact on the environment. Our strategic direction is based upon eight Key Strategic Intentions (KSIs) which reflect what our customers told us they consider important and the views of our wider stakeholder groups. Our KSIs over the next 25 years are:
1. Providing a continuous supply of quality water
2. Dealing effectively with waste water
3. Responding to customers' needs
4. Minimising our carbon footprint
5. Having the lowest possible charges
6. Having the right skills to deliver
7. Maintaining investor confidence
8. Promoting an effective regulatory regime

In setting these KSIs our SDS takes into account the potential impacts of climate change, population growth, tighter regulation and improvements to service. The KSI's formed the basis of our five year business plan, submitted to our financial regulator Ofwat as part of the Price Review 2009 (PR09) process, which covers the period 2010/11-2014/15.</td><td>1.1
1.3
1.4
1.5</td><td>1.1
1.2
1.2.3
1.3
5.1
Appendix 1 (section A1.1)</td></tr>
</table>

We have already had first hand experience of a number of major, severe weather events; very dry summer in 2003, very hot summer in 2006, flooding in 2007, severe cold weather in Dec 2009 – Jan 2010. These have showed the vulnerability of our assets and services and affected our ability to deliver on our KSIs. The impacts of these events are illustrated below. Severe precipitation during May-July 2007 resulted in • 3500 customer reports of both internal and external sewer flooding - associated with just four exceptional storm events • Flooding and loss of production at Mythe Water Treatment Works (WTW) in Tewkesbury, affecting potable water supplies to 150,000 customers for 2 weeks[21] In 2009/10 our operations were significantly affected by the worst winter for 30 years. There were more continuous days with frost in 2009/10 than in any period over the last 10 years and minimum temperatures were lower than the long term average. This resulted in: • More severe ground penetration of frost and greater pipe stress leading to more bursts, requiring an additional £3 million above the annual budget forecast to cover the cost of leakage and repair. • Our ability to provide customers with bills based on actual meter readings as field activities took longer than anticipated as a result of the poor travel conditions. In addition we ceased meter reading activity on a number of days to ensure staff health and safety, this amounted to the equivalent of 2000 hours lost time. • We missed 636 appointments[22] with customers between December 2009 and February 2010 associated financial and reputational impacts. The dry summer of 2003 and the extremely hot summer of, 2006 led to water supply demand challenges both in terms of ensuring sufficient supplies of raw water (drought risks) and provision of sufficient supplies of treated water to satisfy exceptionally high demands. Climate change has therefore already affected our ability to provide a continuous supply of quality water, reduce the risk of sewer flooding and effective treatment of waste water, responding to customer needs and ensuring a high standard of staff health and safety. As a result these events and our response to them has helped inform our five year business plan, our Water Resource Management Plan and our corporate risk management framework.		

21 A full report on the Mythe incident was published in October 2007.

22 An appointment is defined as a specific need to meet with a customer, or a request from a customer to meet with a company representative, to discuss provisions of water or sewerage services, made 24 hours before the agreed meeting time/date.

<table>
<tr><td colspan="3">2. Business Preparedness</td></tr>
<tr><td colspan="3">Has your organisation previously assessed the risks from climate change?
Have you a baseline assessment of the risks of climate change to your business currently? The requirements of the Direction can build upon any existing risk assessment you have in place. Please include a summary of findings from your previous risk assessment(s) in your report.
If so, how were these risks and any mitigating action incorporated into the operation of your organisation?
It is useful to understand whether, and to what extent climate change risks are already incorporated into your business risk management processes at the strategic level.</td></tr>
<tr><td>Response</td><td>Relevant Cranfield Attributes</td><td>Reference to Relevant Section in STW Report</td></tr>
<tr><td>We have taken account of climate change impacts, both from the best available evidence at the time (UKCIP02) and our own experience of extreme events on our operations, as outlined above. We have included these assumptions in our Strategic Direction Statement, the PR09 process and in the Water Resource Management Plan (WRMP). Furthermore climate change is considered within our corporate risk system, Enterprise Risk Management which identified possible causes and consequences of failure to meet objectives and controls to reduce the risk. Climate change has been identified throughout this process as one of the causes of failure to meet company objectives both at a strategic and operational level.

We undertook a detailed review following the 2007 flooding events and as a result instigated a series of improvement programmes to address some of the risks that had been identified, specifically investing in programmes to raise flood defences at high risk sites, increase resilience in water supplies and improve contingency plans. Three key questions were raised as a result:
1. The adequacy of the flood defences
2. The degree of water supply system resilience such that failure of a key asset can be substituted by other means without interruption of services
3. Adequacy of contingency planning.
In response to these questions flood defences have been raised and work is being undertake to reduce the number of properties reliant upon a single source of supply.

In order to address these issues and to ensure delivery against our KSI's over the next five years we will:
• Invest £1,000m to maintain a continuous supply of quality water, focusing on the resilience of the network and treatment works, leakage reduction, water efficiency, flood protection, improved monitoring, distribution mains and communication pipes and in the treatment process itself.
• Invest £1,200 m in maintaining sewers, pumping stations and sewage treatment works, on resolving internal and external sewer flooding, sewage treatment standards and flood prevention.</td><td>1.3
1.4
1.5
2.2</td><td>1.1
1.2.3
1.3
5.1

Appendix 1
Appendix 2</td></tr>
</table>

• Invest £6m in renewable energy, building our adaptive capacity through increasing our proportion of self generation from 20% (200 GWh) to 30% of total energy consumption.		

3. Identifying risks due to the impacts of climate change		
What evidence, methods, expertise and level of investment have been used when investigating the potential impacts of climate change? What evidence have you assimilated to inform your risk assessment? What has been your approach (quantitative, qualitative, scenario based)? What resource (£ / person / days) have been assigned to this assessment? Briefly summarise your approach – in house staff, professional advisors, research expertise?		
Response	**Relevant Cranfield Attributes**	**Reference to Relevant Section in STW Report**
Although climate change was already built into our corporate risk framework and our business planning process it was at a very high level. To meet the requirements of the Direction we therefore carried out a more detailed risk assessment using UKCP09. A project team was formed in June 2009 in order to respond to the consultation and then to meet the requirements of the Adaptation Reporting Power. This core group consisted of staff from Water, Waste Water, Risk, Energy and Carbon Management, Regulation, Strategy and Communications. The project was managed under Severn Trent Water's project management system and had a detailed project plan, risk log and communications plan. A monthly report was made to the Energy & Carbon Steering Group (under which carbon and climate change are governed) and to the Severn Trent Executive Committee on the progress made towards the requirements of the Direction. The team met at least once a month to review progress against milestones and discuss data and risk assessment outcomes and stakeholder engagement. Team members have then worked on identifying key climate change variable, carrying out the risk assessment, identifying possible mitigating options for the priority risks and documenting their work. Where necessary operational experts from within the business were used to help make informed judgements about the risk assessment, mitigation options and the integration of climate change into business as usual. The report has been also been review by the water and waste water leadership teams, General Counsel and Business Continuity. It will be reviewed by the Corporate Responsibility Committee in February. External expertise was sought from UKCIP, other water companies, Alexander Ballard, Mott McDonald and UKWIR.	**1.1** **1.2** **2.1** **2.2** **2.3** **3.1** **3.2** **3.3**	**1.3** **2.2** **3.1** **3.2** **3.3** **7.1** **Appendix 1** **Appendix 2** **Appendix 3** **Appendix 4** **PACT Self Assessment**

We worked with UKCIP on understanding the UKCP09 projections, which have formed the basis of our risk assessment. A case study of our work on use of UKCP09 joint probability plots has been published on the UKCP09 website. In addition UKCIP facilitated a workshop to help us develop a rigorous methodology for identifying and appraising adaptation options. Together we will also develop a case study from this work and its outputs. We also undertook Alexander Ballard's PACT Self-Assessment questionnaire to help us understand how well we are currently adapting to climate change. This highlighted several key areas for us to work on, particularly in relation to scope and coherence, learning and embedding climate change into operations. We believe that in responding to the Adaptation Reporting Power we will address these key issues. Reports from Mott MacDonald, the Met Office and UKWIR, on behalf of the water sector, have both helped us to understand the UKCP09 in more detail specifically in relation to the projection of river flows and soil moisture and sewer flooding. In particular the following UKWIR Reports have been used to help inform our risk assessment and decision making process: • Uncertainty & Risk in Supply/Demand Forecasting • Water Treatment and Climate Change • Climate Change Modelling for Sewerage Networks • Wastewater Treatment and Climate Change • Impact of Urban Creep on Sewerage Systems We also used the Met Office report Commissioned by Ofwat on changes in the frequency of extreme precipitation events for selected towns to help inform our work on sewer flooding. Where necessary data from other sources have been used including: • the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Reports • the Met Office/Ofwat report on precipitation return periods • The Cabinet Office's UK Critical National Infrastructure - Natural Hazards & The Water Industry • HM Treasury's National Infrastructure Plan • The UK Climate Change Risk Assessment Sector Summaries • Pricewaterhouse Cooper's report for Defra on adapting to climate change in the infrastructure sectors We have built upon our existing stakeholder engagement and have attended meetings and arranged workshops with a number of our stakeholders to get their feedback on our approach to climate change risk assessment and its outputs.		

4. Assessing Risks		
How does your organisation quantify the impact and likelihood of risks occurring? Provide here a brief summary of the methodological approach to quantification where this has been possible and your categorisation of likelihood and impact. State what criteria you have used to characterise the significance of the risks (high, medium, low, negligible) and how these have been derived. What level of confidence do you have in the analysis?		
Response	**Relevant Cranfield Attributes**	**Reference to Relevant Section in STW Report**
Climate change is considered as a risk in our Corporate risk management system and has also been considered in our 25 year SDS, our WRMP and our five year business plan. These documents were published too early to take the UKCP09 data into account and did not look comprehensively at all areas of our activities, products and services. In response to the Direction from Defra we undertook a more detailed climate change risk assessment which covered all of our operations and took the UKCP09 data into account. Our risk assessment methodology and process of identifying and appraising options to reduce the risks posed by climate change are outlined in detail in Appendix 1. Initially we identified all of our activities which could be susceptible to the affects of climate change. We then identified which of the UKCP09 climate change variables would have an affect on those activities. Using the data from UKC09 and input from industry experts we then carried out a detailed, quantitative risk assessment. Our analysis was based upon two matrices, each containing two assessment criteria. Each of these criteria were rated out five, one being low/small or likely to occur well into the future, five being high/significant or likely to occur imminently. This generated a score per matrix out of 25 and an overall score out of 50. The first matrix assessed the likelihood against the proximity of the climate change variable having an impact. These two criteria reflected the range of probability and the temporal range used in the UKCP09 scenarios respectively. Our second matrix looked at the severity of the impact and the potential population affected. Our severity score took into account the environmental, social and economic impact. Our population score took into	**2.3** **2.4** **2.5** **2.6** **3.1** **3.2** **3.3**	**1.1** **1.2** **1.3** **5.1** **3.1** **3.2** **3.3** **3.4** **Appendix 1 (A1.2)** **Appendix 3**

account the number of customers likely to be affected by the impacts of climate change. As stated above these were both rated on a scale of 1-5, one being insignificant/small and five being large/ highly significant. Based on the evidence used to analyse the risk and resultant impacts and consequences we assigned each risk a pedigree score on a scale of 0-4. Where risks and their impacts were well evidenced and supported by peer reviewed research we assigned a score of four. Where there was no supporting evidence a score of zero was assigned. This methodology was based upon that used in the UK Climate Change Risk Assessment (UKCCRA) Overall the majority of risks were assigned pedigree scores of one or two. The only peer reviewed data we have used has been UKCP09. Other evidence is based on the extensive knowledge of industry experts whose judgement is informed by experienced. Only a few assigned a score of three. No risks were given a pedigree score of four. Only six risks were allocated a score of zero, due to lack of evidence or expert opinion. These risks were all low scoring in the risk assessment. Based on the expertise used, the projections and inferences made risks were also assigned a confidence grade of high medium or low. Here we also employed the methodology used in the UK CCRA.		

5. Uncertainties and Assumptions		
What uncertainties have been identified in evaluating the risks due to climate change? Where are the key uncertainties in the analysis of the impacts of climate change and what impact do these have on the prioritisation of adaptation responses and risks for your organisation. How have these uncertainties been quantified and, in brief, what are the implications for the action plan? What assumptions have been made? The key strategic business assumptions and methodological assumptions that underpin your analysis of impacts, action plan and analysis of risks. Well-evidenced and justified assumptions are important to the credibility of and confidence in the risk assessment.		
Response	**Relevant Cranfield Attributes**	**Reference to Relevant Section in STW Report**
The UKCP09 data and tools are so wide ranging it is difficult to know which is the best method / tool / dataset to use. For example, we do not know how long the predicted extreme events will last for. We have begun assessing the impacts of climate change based on UKCP09 projections, but further analysis is required and will be carried out in the coming years.	**2.6** **3.3** **4.1** **4.2** **4.3**	**1.3** **4.1** **4.2** **Appendix 1 (A1.2.6)**

To account for the uncertainty around the risks and opportunities we have identified, we have incorporated a likelihood scoring within our risk assessment, meaning that uncertainty forms an integral part of our overall risk rating. Additionally we have applied a pedigree scoring, based on HR Wallingford's methodology applied to the UKCCRA to demonstrate the level of evidence available and the reliability. This pedigree scoring system is shown in Appendix 1. It is likely that the pedigree scorings we have assigned will improve as data become more accurate and as further evidence becomes available. Uncertainty also remains in relation to the way the in which regulatory powers such as the EA and Ofwat will operate in the future. It is likely their policies will change in response to the changing climate projections. We need to ensure stakeholder engagement continues and that we actively work with the regulators in developing sustainable policies and to influence future European Directives. There is also a high degree of uncertainty associated with convective precipitation, which is a driver of sewer flooding. The UKWIR project on the effect of climate change on sewer flooding also identified a number of uncertainties A joint EA / UK Water Industry Research (UKWIR) project is currently underway, which will provide recommendations for the best practice methodology (and Industry Standard) for how to apply UKCP09 tools and data in our assessment of the impact of climate change on our water resources. We will use the outputs from this to help us understand the projections further for use in our 2014 WRMP and our next five year business plan. In putting together this report, carrying out our risk assessment and beginning to make decisions about how to manage the impacts of climate change we have had to make two main assumptions. The first is that we have assumed that the UKCP09 data are the most up to date and constitute the best available evidence. Secondly we have assumed that the water industry will continue to operate within the current financial and regulatory regime. We are therefore assuming that environmental regulation will continue to limit abstraction and tighten discharge consents. In addition we are assuming that Ofwat will continue to regulate the water industry in five year cycles, within a 25 year context. We are also assuming that the Price Review process for 2014 will operate in the same way, to the same timescales as the 2009 Price Review, which allowed 18 months to two years to plan for the next five year period (2015/16-19/20).		**Appendix 2**

6. Addressing Current and Future Risks due to Climate Change

Key Cranfield Attributes: 2.3, 2.4, 2.5, 2.6, 5.1, 5.2, 5.3, 5.4,
Reference to Relevant Section in STW Report: 3.1, 3.2, 5.2, 6; Appendix 1 (Section A1.2 and A1.3), Appendix 3 (Section A3.1, A3.2 & A3.3)

The following tables summarise the priority risks for water, waste water and our support services. The tables also present the options to reduce the severity of these risks and the timescale on which we believe we can implement these options.

Driver	Impact	Consequence	Options	Responsibility	Time Scale	Risk Rating
Water Services see section 3.1 and 5.1.1. Appendix 3 Section A3.1						
Warmer summers (increased summer mean temperature)	Puts pressure on the ecological flow indicators of water bodies.	Reductions to river abstraction licences required.	Reduced leakage Increasing distribution capacity Catchment management Additional water sources Low river flow investigation Increased distribution capacity Works and network resilience	Water Services Environment Agency Landowners in our catchments Local Authorities/Planners and Developers	By 2010s	45
		Reductions to groundwater abstraction licences required.	Reduced leakage Increasing distribution capacity Catchment management Additional water sources Low river flow investigation Increased distribution capacity Works and network resilience	Water Services Environment Agency Landowners in our catchments Local Authorities/Planners and Developers	By 2010s	45
Drier summers (decreased summer mean precipitation)	Puts pressure on the ecological flow indicators of water bodies.	Reductions to abstraction licences required.	Reduced leakage Increasing distribution capacity Catchment management Additional water sources	Water Services Environment Agency Landowners in our catchments Local Authorities/Planners	By 2020s	45

			Low river flow investigation Increased distribution capacity Works and network resilience	and Developers		
Drier summers (decreased summer mean precipitation)	Reduced river flows	Restricted river abstractions. Greater number of regulation days required (e.g. releases from raw water reservoirs to augment river flows)	Reduced leakage Increasing distribution capacity Catchment management Additional water sources Low river flow investigation Increased distribution capacity Works and network resilience	Water Services Environment Agency Landowners in our catchments Local Authorities/Planners and Developers	By 2020s	40
		Increased frequency and duration of compensation releases from boreholes to augment river flows			By 2020s	40
Warmer summers (increased summer mean temperature)	Reduced river flows	Restricted river abstractions. Greater number of regulation days required (e.g. releases from raw water reservoirs to augment river flows)	Reduced leakage Increasing distribution capacity Catchment management Additional water sources Low river flow investigation Increased distribution capacity Works and network resilience	Water Services Environment Agency Landowners in our catchments Local Authorities/Planners and Developers	By 2020s	40
Warmer summers (increased summer mean temperature)	Reduced raw water reservoir levels	Lower reservoir levels crossing drought trigger levels earlier and more frequently	Reduced leakage Increasing distribution capacity Catchment management Additional water sources Low river flow investigation Increased distribution capacity	Water Services Environment Agency Landowners in our catchments Local Authorities/Planners and Developers	By 2020s	40

			Works and network resilience			
Drier summers (decreased summer mean precipitation)	Reduced raw resource availability caused by low rivers flows, low raw water reservoir levels, low groundwater levels, high SMD.	Increased marginal cost of water. Impact on Company Strategy. Redeployment of staff and resources to water stressed areas.	Reduced leakage Increasing distribution capacity Catchment management Additional water sources Increased distribution capacity Works and network resilience Reduce Demand Metering	Water Services Education/Efficiency team Customer Relations Environment Agency Landowners in our catchments Local Authorities/Planners and Developers	By 2020s	40
Warmer summers (increased summer mean temperature)	Increased Soil Moisture Deficit (SMD).	Increased domestic demand.	Water efficiency. Customer metering Increased distribution capacity	Water Services Education/Efficiency team Customer Relations Environment Agency Landowners in our catchments Local Authorities/Planners and Developers	By 2020s	40
Drier summers (decreased summer mean precipitation)	Increased Soil Moisture Deficit (SMD).	Increased domestic demand.	Water efficiency. Customer metering Increased distribution capacity	Water Services Education/Efficiency team Customer Relations Environment Agency Landowners in our catchments Local Authorities/Planners and Developers	By 2020s	40
Waste Water Services see Section 3.2 and 5.1.2. Appendix 3 Section A3.2						
Higher Winter Precipitation	More local sewer flooding	Economic costs and disruption. Customers properties flooded internally and/or	Progressive surface water separation & SuDS implementation.	STW Ltd Local authorities	0-25 years	20

		externally.				
More intense summer storms	More local sewer flooding	Economic costs and disruption. Customers properties flooded internally and/or externally.	Update design standards	STW Ltd Waste Water Services & contractors	12 month s	20
Higher Winter Precipitation	Inundation of Sewage Treatment works from river flooding	Operational failure. Pollution of receiving water. Asset deterioration	Increase in flood defence around treatment works. Movement of critical equipment to higher level	STW Ltd Local authorities Environment Agency	0-25 years	16
Higher Winter Precipitation	Inundation of Sewage Pumping stations from river flooding	Operational failure. Pollution of receiving water. Asset deterioration	Increase in flood defence around SPS. Movement of critical equipment to higher level	STW Ltd Local authorities Environment Agency	5-25 years	14
Low Summer Precipitation.	Reduced water quality	Deoxygenated water, eutrophication, loss of biodiversity. Breech of discharge consent	Develop and agree more appropriate consents. Improve discharge quality where necessary.	STW Ltd Environment agency STW Ltd	0-5 years 5-25 years	12
Higher Winter Precipitation.	Sludge transport to land is disrupted.	Sludge cannot be removed from site. Lost revenue as sludge cannot be deposited on land	Develop alternate sludge transport routes	STW Ltd (for sludge treatment) Local authorities and Highways Agency (for road networks)	0 -25 years	12
Support Services see Section 3.3 and 5.1.3. Appendix 3 Section A3.3						
Warmer Summer Temperatures	Failure of power infrastructure	Operational failure. Increased reliance upon back-up generators and	Understand national Grid contingency plan. Increased self supply of	STW Ltd (Facilities, Energy & Carbon Management)	2020s	28

		renewable supply	renewable energy. Increase fuel storage on critical sites.	National Grid/Central Networks		
Warmer summer temperatures	Reduced raw water availability and higher temperatures. Suppliers unable to continue normal operations	Operational disruption as essential supplies not available when required	Develop/ensure alternative suppliers or products built into supply contract. Purchasing & Supply Chain team awareness of requirements.	STW Ltd (Purchasing & Supply Chain Team) Supply Chain	2020s	28
Increase in extreme events	Increased storminess and high winds causing damage to above ground telecoms equipment	Operational disruption. Reduced customer service.	Contingency plans in place to ensure continuity of land and mobile reception	General Counsel Risk & Resilience	2020s	28
Warmer summer temperatures	Higher temperatures. Increased heat exhaustion of staff	Staff absence and operational disruption. Possible increased operational costs due to increased cooling requirements	Accommodation programme. Consolidation of staff in regional offices built to highest standards	Facilities	2020s	26
Warmer summer temperatures	Higher than average temperatures and reduced reliability of telecommunications equipment	Disruption to business continuity. Operational disruption. Increased maintenance costs	Contingency plans in place to ensure continuity of land and mobile reception	General Counsel Risk & Resilience	2020s	25
Warmer summer temperatures and reduced cloud cover	Higher temperatures and increased sunshine hours leading to increased UV exposure	Higher incidence of skin cancer affecting staff ability to work. Possibly leading to increased litigation	Provision of information on working safely in the sun and appropriate clothing and sun cream.	HR, & H&S business partners	2020s	25

7. Barriers to implementation Adaptation Programme		
What are the main barriers to implementing adaptive action? What do you see as the key challenges to implementation of your action plan? How will these be resourced and addressed? Briefly, what additional work is required? Has the process of doing this assessment helped you identify any barriers to adaptation that do not lie under your control? Interdependencies may arise where others' actions are likely to impact on your ability to manage your own climate change risks. Briefly comment on where this is the case.		
Response	**Relevant Cranfield Attributes**	**Reference to Relevant Section in STW Report**
We have identified a number of key dependencies and interdependencies in undertaking our climate change risk assessment. We have worked closely with our stakeholders to identify these and to determine ways to manage the related risks to achieve the best outcome for all. Key dependencies include : • The Environment Agency's approach to regulation of abstraction licences and discharge consents. We are also dependent upon the EA maintaining flood defences in some areas, as they provide protection for some of our assets. • Ofwat's approach to financial regulations and price setting • Energy distributors 20% of our energy requirement is met through self supplied renewable energy however, we still import around 750 GWh of electricity from the National Grid. Any damage to the energy infrastructure from flooding, extreme temperatures or storms would be detrimental to our ability to pump and treat water and waste water. • Telecommunications, failure of the infrastructure could result failure of our telemetry systems as well as communications with our customers. • Fuel and chemical suppliers and their ability to either manufacture or distribute chemicals for the water treatment process or fuel to power critical plant or vehicles. Key Interdependencies include: • Large landowners, such as farmers, the Forestry Commissions and indeed our own operations in our catchments in order to manage water quality. More sustainable land management practices can help slow the flow of water during storm events as well as helping to reduce diffuse pollution. • Local Authorities who are responsible, under Flood and Water Management Act 2010 for surface water management and the adoption of sustainable drainage systems (SuDS). Managing sewer flooding though surface water management will require effort from local authorities and ourselves	**7.1** **7.2** **3.3** **8.4**	**7.1** **7.2** **8.1** **8.2** **9.1** **9.2** **9.3** **9.4** **Appendix 5**

though surface water/foul water separation in new developments and redevelopment. We are, therefore, starting to work with local authorities to encourage them to use their new powers to progressively reduce the amount of surface water entering the sewerage system.
- Local authorities, developers and Environment Agency to promote water efficiency and the Code for Sustainable Homes

We have identified a number of barriers in adapting to climate change, as identified in our Changing Course document[23], furthermore this document identifies some possible solutions to overcome these barriers. In the process of carrying out a detailed climate change risk assessment we have identified a number of other potential barriers to adaptation.
Key barriers are:

- Lack of a National Adaptation Plan - We need to understand the implications of others sectors adaptation plans and their effects on our operations. Government should communicate its vision to all sectors, promote good practice adaptation, clarify the long term strategy for economic regulation and facilitate dialogue between regulators.
  - We are currently working with stakeholders and will continue this work to ensure that our climate change risks are fully understood. We will, therefore factor the findings of this report into our response to the Water White Paper and other relevant consultations.
- Environmental Regulation - Climate change for the water industry will primarily affect our ability to comply with current legislation controlling our waste water discharge and limits to water abstraction from both rivers and groundwater.
  - We are working closely with the EA to develop a programme of variable discharge consents, where concentration of discharge varies with river level and therefore takes account of dilution. Our project ‘Balancing Carbon and Ecology’ (see Section 5.1.2) is a good example of this. We will also continue to work closely with our stakeholders to develop catchment-wide solutions to minimise diffuse pollution.
  - We believe a model for water trading could also help ease the pressure on abstractions by optimising the use of water resources on a national scale. We will continue to build greater strategic capacity within our own network. We will also use this as an opportunity to ensure more connectivity across company boundaries to enable trading.
  - We will also continue to work with our customers to promote water efficiency, increase metering and reduce leakage within our system to help reduce demand. We will also work to develop relationships with local authorities, planners and developers in our region to promote the building of houses which meet Level 3 of the Code for Sustainable Homes, thereby driving inbuilt water efficiency.

23 Changing Course, delivering a sustainable future for the water industry in England and Wales. Severn Trent Water 2010.

• Economic Barriers - Our ability to adapt depends partly access to finance, through the Price Review Process but also through funding available to government agencies and local authorities. To overcome these we will:
  o Use this risk assessment to inform our AMP6 investment strategy.
  o Test the sensitivity of our water resources and supply network to the range of climate variables using the UKCP09 climate change scenarios.
  o Screen the adaptation options that get promoted in our 2014 Final Business Plan using the process we developed with UKCIP.
  o Work closely with Ofwat to understand how to manage uncertainty and to develop long term innovative solutions, rather than short term capital intensive solutions, taking account of any best practice available.
  o Work with local authorities to share information, experience and knowledge, on sewer exceedence and surface water flow
  o Work with the EA to share information on river and flood modelling
  o Build resilience within our own network and to ensure customers are not reliant upon a single source of water supply
• Evidence and uncertainty - There is still a degree of uncertainty in the climate change scenarios, due to natural variability, modelling inaccuracies and unpredictable future anthropogenic emissions. There is also a high degree of uncertainty over future extreme events such as convectional precipitation, snow, storms and gales. To over come this barrier we will:
  o Continue to engage with climate change scientists to understand better the nature and impact of any change to uncertainty in the models.
  o Work with UKCIP and the data to fully understand the implications and the limitations of the projections.
  o Review changes to the projections in our annual updates of our Water Resource Management Plan and in the development of our AMP 6 Business Plan.
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8. Report and review		
How will the outcome of the adaptation programme be monitored and evaluated and what is the timetable for this? Adaptation programmes are expected to reduce the residual risk to organisations from climate change. What measures will you put in place to monitor this? How do you propose to monitor the thresholds above which impacts will pose a threat to your organisation (including the likelihood of these thresholds being exceeded and the scale of the potential impact)? It is possible that the current risk appetite within your organisation will change on account of the climate change risks identified. How will this be monitored? How will the benefits of the programme be realised and how will this feed into the next risk assessment and options appraisal? Briefly state your plans for the next iteration of your climate change risk assessment. How have you incorporated flexibility into your approach? State whether your approach leaves you open to exploring different pathways in future or whether any of the measures have locked the approach into one particular path, with justification		
Response	**Relevant Cranfield Attributes**	**Reference to Relevant Section in STW Report**
Our most recent Business Plan, submitted to Ofwat in 2009, sets out our investment plan for the period to 2015. Our current Water Resources Management Plan, published in 2010, sets out our strategy for securing sustainable water supplies for the next 25 years. Both of these plans will be updated and resubmitted in 2014, and will be based on our most up to date assessment of risks. These plans will also be informed by the latest UKCP09 climate change scenarios and the implications for our long term water supply and waste water treatment strategy. A number of schemes have already been put in place to manage the risks posed by climate change. Over the next five years we will increase security of supply, reduce leakage, promote water efficiency and metering, reduce sewer flooding, decrease odour and nuisance and meet higher standards for sewage treatment. Delivery of these schemes will be monitored and reported to Ofwat on an annual basis as part of the June Return and to the Environment Agency as part of the Water resource Management Plan Annual Review. Our progress against our KSIs is monitored monthly though our 20 Key performance indicators. These are also reported annually to Ofwat and as part of our Annual Report and Accounts. The data reported in our annual June Return and Water Resources Management Plan Annual Review, forms a significant part of the evidence base we use when preparing our asset investment plans. Because of our established annual reporting process, we have a lengthy time series of service performance data from which we can determine trends. We will continue to add to that time series as we report on progress with implementing our AMP5 investment plan between 2010-11 and 2014-15.	**7.1** **8.1** **8.2** **8.3** **8.5**	**1.1** **1.2** **5.1** **5.2** **6** **6.1** **Appendix 4**

We will reappraise the effects of our programme on an ongoing basis. At each periodic review, we will re-examine our levels of investment, and the effectiveness of our strategy to ensure that they are still appropriate. We will take into account the latest information on climate change as and when it emerges. Wherever possible we aim to improve the resilience of our assets by avoiding the construction of new assets and to work with the natural processes and with other stakeholders to minimise the consequences of climate change. We recognise that this will not be possible in every case. Where we need to construct new assets, we will use the best available information so that they are likely to remain sufficiently resilient to serve the needs of our customers into the future without locking us in to any particular pathway. We will also continue to learn and appraise our response to extreme events such as the conditions we have experienced in 2010 where we have experience high summer temperatures and high demand as well as extreme winter conditions leading to leakage and loss of supply. We are committed to the delivery of all of the schemed funded in the Final Determination by Ofwat. Beyond 2014/15 we cannot currently commit to deliver any adaptation options that were not funded by Ofwat. Our proposal is, therefore to embed the approach employed in this report into our future business planning process. We will be using the climate change risk assessments to inform our next investment strategy. We will use the UKCP09 climate change scenarios to test the sensitivity of our water resources, supply network and waste water treatment processes to the range of climate variables. We will identify and appraise options for adapting to climate change into our 2014 Business Plan and WRMP preparation.		

9. Recognising Opportunities		
What opportunities due to the effects of climate change and which the organisation can exploit have been identified? The risk assessment is also expected to generate opportunities for organisations, have these been captured? What are the key ones and the expected net benefits?		
Response	**Relevant Cranfield Attributes**	**Reference to Relevant Section in STW Report**
A number of opportunities were identified during the course of this assessment related to a number of areas of the business. The UKCP09 projections show that the average winter temperature and the minimum winter temperature are likely to increase by between two and three degrees by the 2080s. If this increase in winter	**6.1**	**3.4** **Appendix 3 (A3.1, A3.2,**

temperature happens as predicted, the change in climate would have a positive effect on leakage in our region through fewer incidences of freeze/thaw which lead to bust pipes . Reducing leakage would enable us to increase the amount of water available for customers without having to increase abstraction volumes. This would be of significant benefit to the environment, and has been identified in our Water Resources Management Plan as a key activity for helping to maintain the supply/demand balance in the future, particularly taking into account increased pressures on resources due to climate change and population growth. Another opportunity may arise from a rise in winter temperatures, which will lead to increased bioactivity within the sewage treatment processes, without the requirement for additional heating. Increased bioactivity will, however, also lead to an increase in demand for oxygen, which is an energy intensive process. Balancing the increased efficiency from the biological process and increased energy consumption due to excess oxygen pumps, we may experience a small increase in energy efficiency as the treatment time will be reduced. Warmer temperatures throughout the year, particularly in autumn, winter and spring are predicted by the UKCP09 scenarios. In addition there are predicted to be fewer days where the temperature drops below 15.5 °C. As a result we could expect our office heating requirement to decrease, resulting in a saving in energy and carbon emissions. It is also probably that warmer winters will reduce the probability of snow, frost and ice. As a result this would also present an opex saving through a reduction in the use of grit/salt. The UKCP09 scenarios show an increase in winter precipitation around 18% by the 2080s. The increased winter precipitation will lead to increased runoff, which in turn will increase river flows during the winter months. The projected change in precipitation could benefit the environment (for example higher river flows will help dilute pollutants such as nitrates and phosphates which are commonly used in fertilisers that run off fields into watercourses) as well as providing an opportunity for us to optimise winter storage and help alleviate flooding by maximising bank side storage. Higher river flows would also aid the recharge of our pumped storage reservoirs which are refilled by water pumped from the rivers during the winter months. The level of the river determines how much water we are able to abstract and store in our "pumped storage" reservoirs – if the river level is low, then abstractions are restricted to prevent the rivers dropping below a sustainable level. More physical resource would be available to abstract, treat and put into supply. Increased potential evapotranspiration as a result of increased temperatures might, however, negate the benefit gained by the increase in winter mean precipitation. Therefore the overall impact on river flows may be less than expected. Increased winter precipitation may also lead to increased infiltration and as a result recharge of groundwater stores and therefore increased physical resource.		**A3.3)**

Appendix 7 PACT Climate Change Adaptation Self Assessment